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C. E. Mendenhall

NATIONAL ACADEMY OF SCIENCES
OF THE UNITED STATES OF AMERICA
BIOGRAPHICAL MEMOIRS
VOLUME XVIII—FIRST MEMOIR

BIOGRAPHICAL MEMOIR

OF

CHARLES ELWOOD MENDENHALL

1872–1935

BY

J. H. VAN VLECK

PRESENTED TO THE ACADEMY AT THE AUTUMN MEETING, 1936

CHARLES ELWOOD MENDENHALL

1872–1935

By J. H. Van Vleck

With the passing of Professor Charles Elwood Mendenhall, at Madison, Wisconsin, on August 18, 1935, America lost one of its leading figures in physical science. Seldom has a man revealed so completely a combination of notable achievement and lovable character.

Charles Mendenhall was born at Columbus, Ohio, on August 1, 1872. He was the distinguished son of a distinguished father. Thomas Corwin Mendenhall, his father, was a prominent physicist, after whom the physical laboratory at Ohio State University is named. The senior Mendenhall was one of the first professors appointed to that institution, and later was in turn president of Rose Polytechnical Institute, superintendent of the U. S. Coast and Geodetic Survey, and president of Worcester Polytechnical Institute. Thus, Charles Mendenhall's scientific heritage was great, and he proved himself worthy of it in every way. His father, too, was a member of the National Academy, and the two Mendenhalls are the only instance of father and son both in its ranks in the physics section.

Mendenhall was of Pennsylvania Quaker and Colonial New England stock. Although, at least in later years, he had no professed denominational religious faith, one always recognized in him the quiet sincerity, simplicity, modesty, and meticulous honesty which one traditionally attributes to Quaker origin and environment. On his father's side, his ancestry * can be traced back to the founders of the Penn colony who came to this country in 1686 and settled in Delaware county, establishing the vil-

* For further geneological data on his father's side, see the biography of Thomas Corwin Mendenhall, written in this series by Henry Crew (Volume XVI, 7th memoir).

lage now called Concordville. In this neighborhood there is, at the present time, a station named Mendenhall on the Octoraro branch of the Maryland division of the Pennsylvania Railroad. His mother, Susan Allen Marple Mendenhall, was born at Columbus, Ohio, and likewise had ancestors of English descent, though not of Quaker affiliation. One of her Colonial forefathers was Major Solomon Allen, who carried Major André back to West Point after André was captured as a spy in the Revolutionary War.

EARLY LIFE

At the age of six, Charles Mendenhall was taken by his parents to Japan, where he spent three years. During that period, only twenty-five years after Commodore Perry's celebrated visit, his father held a professorship of physics in the Imperial University of Tokio. This post was one of four pioneer professorships created by the Japanese government to introduce Occidental science and ways of thought. The other three appointees were W. S. Chaplin, in civil engineering, E. F. Fenollosa, in philosophy, and E. S. Morse in zoology. Mendenhall's contact with Japanese culture and environment during his early boyhood perhaps unconsciously kindled his life-long fondness for Japanese art, and interest in Japanese statesmanship and diplomacy. Furthermore, two of the pioneer professors, Fenollosa and Morse, were instrumental in making the Occident become conscious of the high worth of Japanese art, and probably performed an even more valuable service in bringing the latter back to America than in taking Western science to Japan. Fenollosa became the first authority on Japanese prints, while Morse was ultimately made keeper of Japanese pottery at the Boston Museum of Fine Arts. In Japan, Charles Mendenhall was the childhood friend of Morse's son, John. This friendship continued through later life in America, like that between the two fathers. This contact with the younger and older Morse was doubtless an influence which continued and augmented Mendenhall's appreciation of Japanese Art. Although one thinks first of his love for Japanese prints, Mendenhall retained a lively

interest in other aspects of Japanese culture and customs. In the closing months of his life, he remarked to a colleague that rice was the one food which still appealed to him, stating that this was probably because of Japanese diet in his early days. That same last summer, but, unfortunately too late for reply, he asked a childhood friend, Tsunejiro Miyaoka, to send him maps of the old Tokyo of his boyhood, and of the city of the present day, in order that he might compare the two.

In 1881, at the age of nine, Mendenhall returned with his parents to America. He then spent three years at Columbus, where his father was again professor, and the two following years at Washington. His elementary education was in the public grammar and high schools. His father's acceptance of the presidency of Rose Polytechnical Institute took him to Terre Haute, Indiana, in 1886. Although he was a student at this Institute, he did not matriculate there until after his father resigned as president to become superintendent of the U. S. Coast and Geodetic Survey. He received the degree of A.B. from Rose Polytechnical Institute in 1894. Shortly before graduation, he was elected to Phi Beta Kappa and Sigma Xi. One of his undergraduate friends, A. M. Hood, writes, "Charles was a serious student. I never talked with him much as to aspirations, but I have the impression that he intended to be a teacher and he was considered somewhat of a mathematical 'shark.' He was quiet and reserved but I considered him mighty good company, and our quartet evenings were most enjoyable." His main recreation and avocation was his music. He played first violin in the Rose Polytechnical orchestra, which was rather unusual in that it mustered a well balanced instrumentation of 17 pieces out of a total student body of about 250. In addition, he belonged to a quartet which practised once a week and played a few engagements in small towns surrounding Terre Haute.

During the summer of 1894, Mendenhall assisted George Putnam in making a transcontinental survey of the acceleration of gravity for the Coast and Geodetic Survey. Then he taught physics for a year at the University of Pennsylvania. He took these positions not merely for the experience, but in order to

secure sufficient funds to commence post-graduate work. It was his father's theory that a man should be self-supporting during the period of graduate study, although it was not a question of financial necessity in the Mendenhall family.

GRADUATE STUDY

In the fall of '95, Mendenhall began graduate work at Johns Hopkins University, from which he received the Ph.D. degree in 1898. At this time, the great Rowland was at the peak of his reputation. Nevertheless, Mendenhall does not appear to have been in particularly close contact with Rowland as regards graduate work, though the latter was an intimate friend of his father. About 1896 or 1897 Rowland started working on his printing telegraph, and thereafter had little time to devote to the researches in progress in the laboratory. However, Mendenhall took courses both from Rowland and from Ames, who was subsequently president of Johns Hopkins University. In those days a graduate student was much more "on his own" than he is now. In fact, there is the classical story that when Mendenhall's father, Thomas Corwin Mendenhall, asked Rowland what he did for his graduate students, he answered, "I neglect them," (the last thing, incidentally, that could ever be said of Charles Mendenhall after he became professor). A student was expected to do his own shop work, and did not have the assistance of a corps of mechanics and the like. Naturally, the first attempts of a graduate student in the shop were apt to be rather crude, and Rowland's personal mechanic, whose services were not available to students, referred to Mendenhall and his companions as the "wood-butchers." However, his ability was recognized by the university, which awarded him a fellowship, and by the other graduate students, who regarded him as a man of unusual promise and brilliance. Among his student friends may be mentioned L. J. Briggs, N. E. Dorsey, W. J. Humphreys, W. T. Mather, J. T. Mohler, F. A. Saunders, and C. W. Waidner. Dr. Briggs, now Director of the Bureau of Standards, writes, "During our student days together, I was impressed with Mendenhall's great kindliness, his overwhelming curiosity as to how things worked,

and his immediate readiness to disclose through questions his own lack of knowledge of some subject, in order to remedy the situation on the spot. I think this latter trait may have resulted in part from his intimate and happy companionship with his father, of whom he often spoke."

Because of family ties, summer heat in Baltimore, or absence of shop facilities during vacation at Johns Hopkins University, Mendenhall spent the summer of 1895 at his parents' home at Worcester. Since his father was then president of Worcester Polytechnical Institute, he naturally had access to the shops of that institution. He availed himself of this opportunity to construct during the course of the summer much of the apparatus which he subsequently used at Hopkins.

Mendenhall's problem for his doctor's thesis was one proposed by Reid, with supplementary suggestions from Ames. It was the study of radiation from a black body. Instead of having an ordinary luminous surface, he endeavored to actually construct a "Hohlraum," as theory indicated that the radiation escaping from a small orifice in such a cavity should be that characteristic of ideal black body distribution even though this property is not possessed by the material forming the walls of the cavity. In the latter part of his research for his doctor's degree, Mendenhall had the cooperation of Frederick A. Saunders, who is at present chairman of the physics department of Harvard University but was then likewise a candidate for the Ph.D. at Johns Hopkins. Saunders was at first assigned merely to assist Mendenhall with the apparatus which the latter had already partially constructed, for Saunders was then somewhat the junior of the two in training and experience. Later, however, it developed that there was enough to the problem provided by Mendenhall's apparatus to supply doctors' theses for each of the two men. Mendenhall made his dissertation on the radiation at higher temperatures (500°-1100° C) while Saunders studied a somewhat lower range. The results were published in a joint article which did not appear until three years after Mendenhall received his Ph.D. In his early work on black body radiation, Mendenhall had the benefit of frequent contact with C. G. Abbot, who was then in

charge of the Astrophysical Observatory established by Langley at the Smithsonian Institution. He frequently consulted with Abbot on the construction of sensitive galvanometers, which presented one of the most serious technical difficulties in the radiation problem. An outgrowth of his struggle with galvanometers was a joint paper with C. W. Waidner, who was a fellow graduate student at Johns Hopkins and later a colleague at Williams, on the construction of galvanometers of unusual sensitivity.

Throughout his life Mendenhall retained his interest in the subject of black body radiation. His last paper on this subject was in 1929, on an ingenious electrical method of determining the Stefan-Boltzmann constant which, however, proved to be a disappointment as far as supplying an accurate value of Planck's constant h. There must have been an interesting contrast in refinement and delicacy between the apparatus which he used in 1897 and that which he employed in 1929, since his experimental technique kept abreast of the modern developments in high vacua, electrical thermometry, etc. The original experiments of Mendenhall and Saunders were made at atmospheric pressure, and absorption by CO and H_2O caused a great deal of trouble. As electrical methods were not then available, the black body was kept at a high temperature by means of gas burners. One can imagine the difficulty in maintaining a uniform heated surface by such means. It is thus little wonder that in publishing their doctor's dissertation, Mendenhall and Saunders modestly stated that the results were "largely negative," especially in view of the extensive existing German work.

WILLIAMS COLLEGE

During 1898-1901 Mendenhall was instructor at Williams College. The members of its staff still point with pride to the remains of a dividing engine and other apparatus which he constructed while there. He always retained a great affection for Williams, and in many ways almost regarded it as his Alma Mater, for a variety of reasons. In the first place, he was no longer under the same strain that he was as a self-supporting

graduate student. Also, after all, Williams was a college rather than a technical school, and especially, there was the opportunity for excursions with colleagues into the nearby New England hills. Among his friends at Williams were Ralph Perry, now professor of philosophy at Harvard, and Frank Mather, who later became professor of art and archaeology at Princeton.

UNIVERSITY OF WISCONSIN

In 1901 the calling of R. W. Wood to Johns Hopkins left a vacancy in the physics department at the University of Wisconsin for some one who specialized in light. Mendenhall was appointed assistant professor to fill the position, and, except for a brief interim during the war, he served continuously on the staff at Wisconsin for thirty-four years. His promotion was rapid. He was made associate professor in 1904 and full professor in 1905. Although he was not officially chairman until 1926, he took an active part in the administration of the research activities of the department long before this date. In particular, he was always a vital force in the direction of the research work of graduate students, and his presence was instrumental in making the University of Wisconsin one of the leading centers for graduate work in physics. Among his colleagues in the physics department at various periods of his professorship at Wisconsin may be mentioned G. S. Fulcher, L. R. Ingersoll, Max Mason, J. R. Roebuck, B. W. Snow, W. F. Steve, Augustus Trowbridge, H. B. Wahlin, Warren Weaver, R. C. Williamson, and the writer. Trowbridge left Wisconsin in 1906 to accept a professorship at Princeton, but the intimate friendship between him and Mendenhall continued. They visited each other frequently for long periods, and carried on joint researches. War work also brought them together in Washington in 1917-20.

No biography of Charles Mendenhall would be at all adequate which did not stress his great and affectionate interest in his students. Never have I known a man who followed the research activities of his students with more devotion. Mendenhall was a teacher in the true sense of the word. By this I do not mean mere class room lecturing. Such instruction was never his first

love. Rather it was by informal conference over research projects and difficulties that he did so much to guide and inspire the graduate students at Wisconsin. At almost any hour of the day he might be seen in his office talking to one or more men. I do not mean to imply that he "mollycoddled" his students. This was something which never could be said of Mendenhall, and he expected them to build their apparatus themselves.

He had the objectivism characteristic of the true scientist. He knew that if there was a problem to be solved, and this could be done by a student, so much the better, for in this way the student would gain a wealth of experience whereas a more mature professor would not profit correspondingly if he performed the experiment himself. One always felt that Mendenhall's aim was to get the research done, not to advance his own reputation. A colleague once remarked, "Mendenhall would be a greater experimentalist if he did not give so much time to his students." This remark is probably true, if a man's scientific career is judged simply by the volume of papers bearing his name. The total output of a laboratory is a more altruistic measure. Over thirty-five students took their doctorates under Mendenhall while he was at Wisconsin, many of whom have had notable research careers. In influence on their lives and scientific attainment, the work of Charles Mendenhall bulks large.

Although Mendenhall's teaching work was, first and last, primarily of a graduate nature, one should not form the impression that he never gave undergraduate instruction. His undergraduate work was naturally greatest during his early years at Wisconsin, but it is interesting to note that in 1931, when the University was feeling the brunt of the depression, Mendenhall unselfishly added the difficult experimental lectures in one of the beginning courses in physics to his teaching schedule in order to lighten the burden on the department caused by a curtailment in personnel.

Mendenhall was instrumental in bringing to Wisconsin many noted European physicists as visiting lecturers for periods ranging from a week to a year. Among them may be mentioned Born, Brillouin, Debye, Dirac, Fowler, Franck, Lorentz, Schrö-

dinger, Sommerfeld, and Wentzel. Contact with these men was a valuable stimulus to the work of the department, especially as their visits were mostly during the period before America became of age in mathematical physicists. In 1922, an imposing symposium in theoretical physics was held in Madison, with H. A. Lorentz presiding. In his knowledge of foreign physicists and negotiations with them, Mendenhall was aided by the various European trips which he made while a professor at Wisconsin, either during sabbatical leave or summer months. His visit to England in 1919, as scientific attaché, will be described later.

After 1926, Mendenhall served continuously as chairman of the department until his death. Under his supervision, it ran with a rare smoothness and harmony, due largely to the universal respect for his personality, and confidence in his judgment. Other members of the department regarded him almost as a father. Some of the most difficult decisions which a chairman must face are in connection with the appraisal of the young men in his department, such as assistants subsidized in graduate work. In his attitude towards them he showed freedom from prejudice, and a proper balance between scientific integrity and human kindness, two virtues which, alas, are often incompatible. He did not hire and fire excessively in an over-zealous search for outstanding men. He recognized the strong points of even the humblest and the weakest graduate student, but he did not let his sympathy for them degenerate into sentimentality, nor did he develop the philosophy that the under-dog is always right, a foible particularly common in academic circles.

In the administrative affairs of the University outside his own department, Mendenhall displayed a moderate but adequate interest, and he always had a deep feeling of loyalty to his institution. He was not by temperament a "committee man," nor was he a too-conscientious attender of faculty meetings, for his real heart and soul were in the research activities of his department. However, these statements should not be construed as meaning that he escaped all committee work. Near the end of his life he headed one of the most important university committees, that which selected the candidates for honorary degrees.

SCIENTIFIC RESEARCH WORK AND PUBLICATIONS

We have already alluded to Mendenhall's continued interest in pyrometry and the optical radiation from hot bodies, which, directly, or indirectly, motivated many of his research problems. His most notable achievement in this field is probably the invention of the V-wedge method in 1911. Here a long strip of the radiating material is bent (or else two strips joined together), so that the cross-section is that of a narrow V. The material is heated by passing a current through it longitudinally. The radiation escaping from the interior of the "V" is that characteristic of an ideal black body, since the inside serves as substantially a "Hohlraum" because of the many reflections before escape. The radiation from the outside is, on the other hand, that characteristic of the metal itself. The great advantage of the method is that, besides the uniformity of temperature assured by electrical heating, it is possible to compare, at one and the same time, and hence under similar conditions, the characteristic and black-body radiations. This device constitutes a material simplification in pyrometry, as it enables one to determine the proper corrections needed to obtain the true from the empirical temperature. Mendenhall and his students used the V-wedge method to study the radiations of many materials—tungsten, tantalum, carbon, and others. They also employed it to make an accurate determination of the melting-point of molybdenum.

One of his interesting earlier papers was on the ring pendulum. Such an instrument consisted of an oscillating body bounded by two concentric cylinders, with the inner surface resting on a knife-edge. This problem was an outgrowth of his work with the Coast and Geodetic Survey, and was also a heritage from his father. The older Mendenhall had hoped to work on this kind of pendulum, but became occupied by presidential duties at Worcester Polytechnical Institute, and referred the project and its supporting grant from the National Academy of Sciences to Charles. The latter showed that accurate determinations of g could be simply made by means of the ring

pendulum, but it is rather difficult to determine exactly the degree of precision, as the experiments were made at Madison, while the best available standard determinations for comparison are at Washington.

During the last fifteen or so years of his life, research in physics was everywhere dominated by problems growing out of the quantum theory of atomic structure. It is thus natural that during this period Mendenhall turned his attention increasingly to the photoelectric effect and thermionic emission, where he and his students made notable contributions. With characteristic patience and thoroughness, they showed that it was a matter of prime importance to purify the surface by very protracted outgassing, far longer than previously thought necessary. Only in this way was it ultimately possible to secure agreement between the thermionic and photoelectric thresholds. As we have intimated, Mendenhall was very generous in turning problems over to students, so that much of his research scarcely comes to light in the bibliography. In particular, it is rather startling that except for presidential or other general addresses, the list of his publications gives no evidence of his continued interest in the photoelectric effect, and of his real influence on this field through the work of his students. In fact, the University of Wisconsin was for many years the country's leading center for research on photoelectric problems.

A noteworthy characteristic of Mendenhall's research was his breadth of interest, shown by the varied nature of his investigations, although most of them could be grouped under the general heading, "properties of the solid state." Seldom could a man more properly be called an "all-round" experimental physicist. His standards of publication were very high. The caution, patience, and thoroughness with which he prepared his articles might well serve as a model and antidote for those too prone to rush rapidly into print. Mendenhall was by temperament a coöperator rather than an individualist. So it is not surprising that a considerable number of the papers listed in the bibliography were written jointly, the other author being sometimes a man of established reputation, sometimes comparatively ob-

scure. The article with R. W. Wood on the effect of electric and magnetic fields on the emission lines of solids was a pioneer contribution in a field which is today attracting increasing attention. It was an indirect result of the war, as the latter prevented Mendenhall from going to Europe for his sabbatical in 1915, so he went to Johns Hopkins for a semester instead.

A very pretty experiment, though not one of his most important, was one made jointly with Max Mason on the stratified subsidence of fine particles, a problem suggested by Warren Mead of the Geology Department at Wisconsin (now chairman at Massachusetts Institute of Technology). Mendenhall and Mason showed, both theoretically and experimentally, that particles immersed in a fluid tend to settle in strata when the two opposite walls of the containing vessel are at different temperatures. This behavior is a thermal effect, each stratum being at a different temperature. Rather spectacular stratified colorization effects can be obtained when the lines of flow are demarked by using particles of fluorescein.

We must not overlook Mendenhall's contributions to the elementary text-books of physics. He never wrote a complete volume himself, but composed the section on heat in the third and all subsequent editions of "Physics for Students of Science and Engineering" edited by A. W. Duff and written by a variety of authors. This book has run through many printings and is probably the most popular text in engineering colleges today. In the closing year of his life, he wrote about forty percent of a new work, "College Physics," by C. E. Mendenhall, A. S. Eve, and D. A. Keys, the last two being professors of physics at McGill University. He knew that he did not have long to live and was anxious to place his financial affairs in the best possible shape. He died a week before the appearance of the first finished copies, but he did read with great care both the galley and page proofs, and showed an iron nerve in dealing with this rather laborious task during the last months of his life. In fact his last work on the book was only two days before he entered the hospital.

OTHER SCIENTIFIC ACTIVITIES AND HONORS

Mendenhall was accorded the recognition which comes to a man of the highest scientific standing. He was elected to the National Academy of Sciences in 1918 and was chairman of the Section of Physics during the period 1924-1927. Other scientific organizations to which he belonged include the American Philosophical Society, the American Academy of Arts and Sciences, the American Physical Society, the Optical Society of America, the American Association for the Advancement of Science, and the Cosmos Club. In each case he had the rank of fellow if this distinction existed.

He was president of the American Physical Society from 1923-25. At previous dates, he had served terms as associate editor of the Physical Review, and as councillor of the American Physical Society. As a past president of the Society, he was privileged to attend its council meetings continuously from 1925 on, and his presence and opinions were always appreciated. He was vice-president of the Optical Society of America in 1921. Later he was on the editorial board of the Journal of the Optical Society. He was also an associate editor of the Reviews of Modern Physics. Among his incidental scientific activities were participation in the annual assay of the U. S. Mint in 1909, and membership on the research committee of the Westinghouse Laboratory. He spent parts of two summers, about 1913, in research at the Nela Laboratory in Cleveland, and was at times a guest in the private laboratory of Loomis at Tuxedo.

He was elected vice-president of the American Association for the Advancement of Science in 1929. The writer remembers hearing in Cleveland in 1930 his interesting retiring vice-presidential address on "Recent Developments in Photoelectricity," in which he so aptly described the Pauli exclusion principle as a "piece of social legislation to avoid the overcrowding of electrons," a characterization which has since become more or less classic.

In 1926 he went abroad as a travelling professor for the International Education Board to assist in a broad survey of

physical science in Europe. This appointment was a distinct recognition of Mendenhall's wide ability and judgment.

Particularly noteworthy were his connections with the National Research Council. As chairman of the Division of Physical Sciences of this organization, from 1919 to 1920 and as member for a longer period, he was influential in effecting the transition from war-time to peace-time activities of that body. When the National Research Council sponsored the International Critical Tables, he was made a member of the editorial board. His greatest service for the Council, however, was on the Board for National Research Fellowships in Physics, Mathematics, and Chemistry to which he belonged since 1924, or for practically its entire existence. The composition of the Board included three representatives in physics. Mendenhall's colleagues in this capacity were K. T. Compton, R. A. Millikan, and later F. K. Richtmyer. To the three physical representatives fell the brunt of the responsibility of the selection of the appointments to the National Research Fellowships in physics. These fellowships have been an enormous factor in bringing America from a secondary to a leading place in pure physics inside of the last fifteen years, especially in the atomic and theoretical aspects. Mendenhall took very conscientiously his share of the responsibility of selecting the appointees. I can vividly remember his poring assiduously, and of course sometimes a little wearily, over the laundry cases which were shipped him from the central office in Washington, loaded, surprisingly, not with clothes, but with the detailed credentials of many dozen applicants. As far as I can judge, there has been remarkably little criticism of the N.R.C. fellowship appointments in physics, despite the rather tenuous decisions that must sometimes be made. I am told by a member that Mendenhall's presence on the board helped signally in the establishment of high objective standards.

WAR RECORD

In 1917, Mendenhall was called to Washington, supposedly for a few weeks. Actually, he was away from Madison over

three years. He was made a major in the Science and Research Division of the Signal Corps. R. A. Millikan was at the head of this division, which was later transferred to the aviation corps, and Mendenhall was his right hand man and personal friend. It is hard to attribute to Mendenhall any one specific accomplishment, as he served in a roving capacity, supervising the activities of many different sections, the work of which was quite varied. Because of his wide background, his advice proved invaluable on many occasions. Through his official position he played an important part in the organization of American scientists for war service. He was especially active in handling scientific devices and inventions for war purposes, and in selecting scientific personnel for their development and use. At that time, the aeroplane was somewhat of a novelty in military circles, and its advent presented a variety of research problems which accounted for a substantial part of the work of the division. (Incidentally, the bibliography of his publications includes a survey of aeronautical instruments which he wrote for the Aerial Age Weekly; this article was a direct result of his war-time activity and interests.) Such subjects arose as finding vibrationless mountings for aeroplane cameras, indication of direction changes by the gyroscopic principle, covers for gasoline tanks which would prevent their being ignited by bullets, etc. The offices of the division were on 16th Street, but the experimental work was done either at the Bureau of Standards or the Langley flying field. Extensive aeroplane tests were also made at Dayton, Ohio, where for a while Mendenhall went about once every week. He spent part of the summer of 1917 at New London, and was influential in starting the organization of the experimental station there.

Mendenhall wore the army uniform, not because he loved brass buttons, but because it was required, probably inasmuch as around Washington a uniformed man could command more attention in connection with requests for equipment, etc., necessary to the research work. He was never a lover of red tape, and fortunately a regular army captain was detailed to attend to the routine military correspondence of the division. Military formality and Quaker simplicity are scarcely compatible. He was

told he must issue orders as to when the young lieutenants under him should wear overshoes. Forthwith, he assembled them together, and solemnly commanded them to wear overshoes "whenever they d— pleased." On the crowded street cars enroute to the Bureau of Standards, Mendenhall sometimes held Warren Weaver (now director of Physical Sciences for the Rockefeller Foundation) on his lap to give more room. One can imagine the consternation of army ritualists at such intimacy between a major and a private.

Immediately following the war, in 1919, he was transferred from aviation to the Department of State and as successor to Dr. Henry A. Bumstead, he served for six months as scientific attaché to the American Embassy in London. At the same time he acted as London representative of the Research Information Service. He was one of the group which went to Brussels in 1919 to participate in the organization of the International Research Council and the allied unions. While in Great Britain, he enjoyed the companionship of many leading English physicists —Bragg, Rutherford, Schuster, Thomson, and especially A. V. Hill, in biophysics, with whom he had much discussion on recalcitrant galvanometers, a subject which had interested him ever since his doctor's thesis.

The National Research Council at first functioned largely through the Research Division of the Signal Corps, and started as a war time organization. In fact, Mendenhall's initial wartime appointment was under the joint auspices of the Signal Corps and the National Research Council. His post-war services in the latter organization have been cited earlier in this memoir.

FAMILY LIFE

On February 14, 1906, Mendenhall married Dorothy M. Reed, of Talcottville, New York. Their acquaintance had been one of long standing. Miss Reed was a graduate medical student at Johns Hopkins University while Mendenhall was working for his Ph.D. in 1895-1898. During that period, he saw her often

and was a devoted friend. She received her M.D. from Johns Hopkins University in 1900, and (in 1901-2) was the first woman to be given a fellowship by this institution. Prior to her marriage, she had a distinguished record in medical research, and discovered the Dorothy Reed cell, which is the diagnostic cell of Hodgkin's disease. Also, she is a recognized authority on matters of child health. In fact, her desire for a professional career made their courtship one of long duration. In her married life, she has continued her interest in the medical care of small children. She established a chain of free clinics for them at Madison in 1915, and has served ever since as the sponsor and as one of the doctors. She has been a lecturer at the University of Chicago, and elsewhere, and is a medical officer of the Children's Bureau in Washington. She has served on the faculty of the University of Wisconsin since 1913, originally as an assistant professor and later as a lecturer. Mrs. Mendenhall was awarded an honorary degree recently by Smith College, her alma mater.

Mendenhall's two surviving sons, Thomas Corwin and John Talcott, are both entering professional careers. Thomas, the older of the two, received his A.B. cum laude from Yale in 1932. He spent three years at Oxford on a Rhodes Scholarship in 1933-36. The coming year he will be an assistant in the history department at Yale University. John, the younger son, graduated from Harvard in 1935, cum laude also, and is at present a student in the Harvard Medical School.

Mendenhall always took a tremendous interest in his children, and a natural pride in their accomplishments. I have never seen him look happier than when, just after the award of the Rhodes Scholarship to his son, Thomas, the graduate students in physics at Madison began the weekly colloquium by giving a Wisconsin sky-rocket cheer for "Tom Mendenhall's father."

At Madison, Mr. and Mrs. Mendenhall lived in a large house within walking distance of the University. If their home life could be summarized in one word, this would be "hospitality," especially where physicists are concerned.

They showed a genuine kindness to any physicist who was at Wisconsin, from the humblest graduate student to the most

distinguished visiting professor. Mendenhall's concept of the duties of a chairman involved responsibilities which did not end when he set foot outside the physics laboratory. On almost any Sunday afternoon. Mr. and Mrs. Mendenhall were "at home" to the staff and students of the department. If an overcoat was wanted for a needy assistant, or if a dinner party was in order for a Nobel prize winner passing through Madison, they managed to provide it. Particularly noteworthy was Mrs. Mendenhall's constant and well-qualified attention to the medical care of the children of the young married instructors in the physics department.

Although Mendenhall had a natural and praiseworthy interest in all colleagues in the physics profession, and was always willing to "talk shop" with them, the impression should not be gathered that his circle of friends was confined to physicists. He was a member of at least three dining or literary clubs, and socially was one of the prominent members of the Wisconsin faculty.

OTHER INTERESTS

Mendenhall's fondness for art was by no means confined to the Japanese form, which has already been mentioned. Also, we have described his musical activities in student days. His keen appreciation for good music continued throughout his life. During his earlier years in Madison, he continued to play in string quartets. About 1920, however, he gave up playing the violin. He was active in musical circles, and was for a period a director of the Madison Orchestral Association, which brought leading symphonies and soloists to the city.

Mendenhall's love of art and beauty is nicely revealed in a diary which he wrote intermittently during his wedding trip to Europe in 1906. Part of this describes in considerable detail an important eruption of Vesuvius, which naturally interested a physicist. The rest, however, is largely an appreciation of the romantic hill towns of Italy. For instance, he says, "Subiaco, when it appears suddenly, seems as much more picturesque than Tivoli as Tivoli is than—Hoboken, say. A rushing stream—two fine bridges—a cone of houses crowned by a citadel—and

backed by snow covered mountains, for the Sabines are the foothills of the Abruzzi, which boast the highest mountain in Italy."

Mendenhall played tennis occasionally in his early years, but he always continued his membership in the faculty tennis club at Wisconsin, possibly partly for the occasional use of his children, but primarily because he believed in the cause. His chief outdoor activity, however, was fishing—a peaceful sport for a peaceful man. It was mainly dry-fly fishing for trout in rapid streams which appealed to him. Whenever he was too tired with hard work, he would depart for a fishing trip in central or northern Wisconsin. For longer fishing expeditions, he would occasionally go to Colorado, Canada, or the Black Hills. On these trips he was sometimes accompanied by his son, John, or by the late Professor Neil Dodge, who was chairman of the English department of the University of Wisconsin and was perhaps Mendenhall's most intimate friend in Madison. Fishing was more to Mendenhall than a mere sport; it was a great solace and an escape from the cares of every day life. He had fished since childhood. A lovely stretch of water shaded by beautiful trees inspired him with joy, and gave him a feeling that all was right in the world.

The mechanics of housekeeping never appealed particularly to Mendenhall. His desk at Sterling Hall (the Physics Laboratory at Wisconsin) was always a great comfort to me, as it could almost invariably be found in even greater apparent disorder and more cluttered with papers than my own. He had, however, a sixth sense for the particular cluster in which a given letter accumulated, and was always quite bothered when the secretary placed his desk in order. He had two offices in the building, and he greatly preferred the one in the basement, which had less of a swivel-chair appearance and which was nearer to the research rooms. He spent much time in the students' own rooms, talking with them about their work, and I often had difficulty in finding him when his secretary told me that he was "in the building" but was not in either of his own two offices. When he became interested in "talking shop" he did not always bother

to hunt up an ash tray, and once his graduate students presented him with a brushbroom to serve instead.

CLOSING YEARS OF HIS LIFE

During his last years, Mendenhall was not in especially robust health, and thirteen months before his death he was told by physicians that he had an incurable disease, and that he could probably expect only a year or two to live. Such news could not fail to be a shock to a man who was then only 61 years old, and in the prime of his scientific work. His serene demeanor and quiet fortitude during this trying period were testimonials of a character at peace with the world. He never told even his most intimate friends of his condition, and kept plugging away at the work of the laboratory with a freedom from complaint which was really heroic. When, later, more severe illness took him to a hospital, not far from Sterling Hall, his room there served as an office to which graduate students and instructors—"my men," as he called them,—could come for the discussion of their research problems. To the very end he retained an interest in all the affairs of the department. It was perhaps fitting that a great scientist, who was born on a university campus and had spent all his life in an academic environment, should die in a university hospital only a stone's throw from the physics laboratory which he loved so dearly.

BIBLIOGRAPHY

The radiation of a black body. (With F. A. Saunders.) Astrop. Journ., vol. 13, no. 1, 1901, pp. 25-47.

On galvanometers of high sensibility. (With C. W. Waidner.) Amer. Journ. Sci., ser. 4, vol. 12, no. 70, 1901, pp. 249-62.

On the luminous efficiency of the carbon filament. Phys. Rev., vol. 20, no. 3, 1905, pp. 160-2.

The melting points of rhodium and iridium and the use of the Nernst glower in high temperature measurements. (With L. R. Ingersoll.) Phys. Rev., vol. 25, no. 1, 1907, pp. 1-15.

On certain phenomena exhibited by small particles on a Nernst glower. (With L. R. Ingersoll.) Phil. Mag., vol. 15, no. 86, 1908, pp. 205-214.

The absolute value of the acceleration of gravity determined by the ring-pendulum method. Mem. Nat. Acad. Sci., vol. x, 1911, pp. 1-23. (Note: First published as a separate in 1905, and later—1911—as a part of vol. x.)

A method of measuring the susceptibility of weakly magnetic substances and a study of the susceptibility of alloys of bismuth with tellurium and thallium. (With W. F. Lent.) Phys. Rev., vol. 32, no. 4, 1911, pp. 406-417.

On the fusion of carbon. (With O. P. Watts.) Phys. Rev., vol. 33, no. 1, 1911, pp. 65-9; also published in German, Ann. d. Phys., vol. 35, 1911, pp. 783-789.

Notes on optical pyrometry. Phys. Rev., vol. 33, no. 1, 1911, pp. 74-6.

On the emissive power of wedge-shaped cavities and their use in temperature measurements. Astrop. Journ., vol. 33, no. 2, 1911, pp. 91-97.

The relation between black-body and true temperatures for tungsten, tantalum, molybdenum, and carbon, and the temperature variation of their reflecting power. (With W. E. Forsythe.) Astrop. Journ., vol. 37, no. 5, 1913, pp. 380-390.

The melting-point of molybdenum. (With W. E. Forsythe.) Astrop. Journ., vol. 38, no. 2, 1913, pp. 196-198.

High temperature measurements with the Stefan-Boltzman law. (With W. E. Forsythe.) Phys. Rev., ser. 2, vol. 4, no. 1, 1914, pp. 62-70.

The effect of electric and magnetic fields on the emission lines of solids. (With R. W. Wood.) Phil. Mag., vol. 30, no. 176, 1915, pp. 316-320.

A determination of the Planck radiation constant C_2. Phys. Rev., ser. 2, vol. 10, no. 5, 1917, pp. 515-524.

Aeronautic instruments. Aerial Age Weekly, vol. 12, nos. 20, 21, 1921, pp. 512-515, 537-539, 549.

The stratified subsidence of fine particles. (With M. Mason.) Nat. Acad. Sci., Proc., vol. 9, no. 6, 1923, pp. 199-202.

Theory of the settling of fine particles. (With M. Mason.) Nat. Acad. Sci., Proc., vol. 9, no. 6, 1923, pp. 202-207.

The constitution of solids. Science, vol. 59, 1924, pp. 219-230. (Presidential address, American Physical Society.)

Electronic phenomena at the surface of metals. Frank. Inst., Journ., vol. 201, no. 3, 1926, pp. 259-278.

The use of the wire method for the melting point of palladium. (With C. L. Utterback.) Journ. Optical Soc. Amer., vol. 15, no. 1, 1927, pp. 62-63.

A radiation method of measuring strain in glass. (With L. R. Ingersoll and N. H. Johnson.) Journ. Optical Soc. Amer., vol. 15, no. 5, 1927, pp. 285-289.

A determination of the Stefan-Boltzmann constant of radiation. Phys. Rev., vol. 34, no. 3, 1929, pp. 502-512.

Recent developments in photoelectricity. Science, vol. 73, 1931, pp. 107-113. (Retiring address as vice-president of Section B of the American Association for the Advancement of Science.)

TEXTBOOKS

Physics for students of science and engineering, Third edition. (With A. W. Duff, editor; E. P. Lewis; A. P. Carman; R. K. McClung; and W. Hallock.) P. Blakiston's Sons and Co., Inc. Philadelphia. 1912. pp. 205-312. The last edition is the seventh (With Duff, Birge, Hall, Carman, and Knipp), 1932; pp. 191-295 by Mendenhall.

College physics. (With A. S. Eve and D. A. Keys.) D. C. Heath. New York. 1935.

OBITUARIES OF CHARLES ELWOOD MENDENHALL

Science, vol. 82, 1935, pp. 317-318, by Karl T. Compton.

Review of Scientific Instruments, vol. 6, 1935, pp. 291-292, by Leonard R. Ingersoll.

William Duane

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BIOGRAPHICAL MEMOIR

OF

WILLIAM DUANE

1872–1935

BY

P. W. BRIDGMAN

PRESENTED TO THE ACADEMY AT THE ANNUAL MEETING, 1936

BIOGRAPHICAL MEMOIR OF WILLIAM DUANE

1872–1935

By P. W. Bridgman

William Duane was born in Philadelphia on Feb. 17, 1872, the son of Charles William Duane and Emma Cushman (Lincoln) Duane. He was a descendant in the fifth generation from Benjamin Franklin, the family line running as follows: Benjamin Franklin's daughter Sarah married Richard Bache, a native of England, who held important offices in the Colonial Government. They had seven children, of whom the fourth, Deborah, married William John Duane. William John Duane was the son of William Duane, who in his capacity as editor of the Philadelphia *Aurora* was influential in bringing on the War of 1812. William John Duane was Secretary of the Treasury of the United States under President Jackson, but resigned, or was dismissed from his office, for refusing to remove the government deposits from the United States Bank at the order of the President.

From Richard and Sarah Bache was also descended, in the second generation, Alexander Dallas Bache, Superintendent of the United States Coast Survey for many years, and one of the founders of the National Academy of Sciences.

William John Duane and Deborah had nine children, of whom the oldest, William, married Louisa Brooks. From this union there were two children, a son and a daughter. The son, the father of our William Duane, was the Rev. Charles William Duane, at one time rector of St. Andrew's church in West Philadelphia, and during a period of nearly fifty years rector of a series of parishes in Pennsylvania, New Jersey, and Massachusetts. Rev. Charles William Duane married Helen Frances Lincoln, a descendant of the Rev. Andrew Eliot of Boston, of whom President Eliot of Harvard was a great-great-nephew. By her he had a daughter who died in infancy, and a son, Russell Duane, at present a prominent practicing lawyer in Philadelphia. On the death of Helen Frances, Charles William Duane married her younger sister, Emma Cushman Lincoln,

by whom he had two daughters, one long since deceased, and the other Louise Duane, now Mrs. Bodine Wallace, and one son, our William Duane.

Duane was graduated from the University of Pennsylvania in 1892 as valedictorian of his class, with the A.B. degree. From Harvard he received the A.B. degree in 1893 and the A.M. in 1895. From 1893 to 1895 he served as Assistant in Physics at Harvard, and in 1895, in collaboration with Professor John Trowbridge, published a research on the velocity of electric waves on wires. As holder of the Tyndall Fellowship of Harvard University he studied from 1895 to 1897 at Göttingen and Berlin, receiving the Ph.D. degree from Berlin in 1897. Four papers on electrical topics were the result of this period. One of them, on thermo-electric circuits composed of electrolytes, was done under the direction of Nernst, and probably contained the material of his thesis, although no explicit statement appears to this effect. On his return to this country, he accepted a position as Professor of Physics at the University of Colorado, a position which he held from 1898 to 1907. During this period he married, in 1899, Caroline Elise Ravenel of Charleston, South Carolina, by whom he had four children, William, Arthur Ravenel (now deceased), John, and Magaretta. During the Colorado period eight papers were published. It is probable that the facilities for consistent research were not good at Colorado, and the titles of the papers would suggest that Duane had to content himself with rather miscellaneous outlets for his impulse for creative work.

The next period embraces the years from 1907 to 1913, when he was in residence in Paris, where, in the laboratory of Madame Curie at the Sorbonne, he carried out a number of researches on various aspects of radioactivity. Seventeen papers were the result of this period. Although none of them was in direct collaboration with Madame Curie, his contact with her was close. It is reported that when Madame Curie visited America some years later she replied, in response to the question as to what she wished most to see in the United States, "Niagara Falls, the Grand Canyon, and William Duane." His papers

from this period were mostly concerned with various properties of α rays from radioactive sources, and with accurate measurements of the heat generated by radioactive disintegration.

Duane's experience with radioactivity coincided with rapidly increasing activity in the medical profession in various parts of the world in experimentation with the possibility of applying radium and X-rays in the treatment of various diseases, especially cancer. About the year 1913 the wave-like nature of X-rays had been established by the work of Laue and the Braggs, and the γ rays from radium were known to be essentially a penetrating X radiation. It was evident, therefore, that the adequate application of X-rays and radium to the treatment of cancer was, at least in its initial stages, a problem involving many physical aspects. It was natural that the newly founded Harvard Cancer Commission should seek the services of a man with competent training in radioactivity, which at that time meant almost inevitably some one trained in Europe. The Harvard Physics Department at the same time had a vacancy because of the retirement of Professor John Trowbridge, and was anxious to find a young man, with a new line of promising work for the future, and whose subject might possibly at the same time be such that he could carry on the use of Professor Trowbridge's 50,000 volt storage battery, an unique instrument, and one which later played an important part in many of Duane's precise measurements. Duane combined in a singularly fortunate degree the qualifications for these two positions, and in 1913 he accepted a joint appointment as Assistant Professor of Physics in Harvard University and as Research Fellow in Physics of the Cancer Commission. In 1917 he was promoted to Professor of Bio-Physics, a title of which he was very proud, esteeming it, with probable correctness, to be the first of its kind in America. Between 1928 and 1933 his official title with the Cancer Commission was "Member of the Cancer Commission," and from 1933 until his retirement, "Research Fellow in Physics" again. On his retirement in September, 1934, he became Professor of Bio-Physics Emeritus.

As would be expected, he divided his time between the Cancer Commission at the Huntington Hospital, and the Jefferson Physical Laboratory of Harvard University, and his salary was carried on the budget of both organizations.

Duane served as Councillor of the Société de Physique during the years 1920-23, as Chairman of the Division of Physical Sciences of the National Research Council 1922-23, as President of the Society for Cancer Research during 1923, as Vice-President of section B of the American Association for the Advancement of Science during 1927-28, delivering the address of the retiring Vice-President on "The General Radiation" at the Nashville meeting in December, 1928. He presented invited papers at the symposium held in New York in December, 1917, by the sections of chemistry and physics of the American Association for the Advancement of Science on the structure of matter, and at the symposium of the section of physics of the American Association for the Advancement of Science held at St. Louis in 1920 on phenomena in the ultra violet spectrum, including X-rays. He was one of the invited participants at the Volta Congress of Physicists at Lake Como in September, 1927, and an American representative at the International Conference of the Grand Council of the British Empire Cancer Commission in London in July, 1928, and at the Second International Congress of Radiology held at Stockholm, July 23-27, 1928.

In 1922 he received the John Scott Medal and Certificate, with a premium of $800, from the Board of Directors of City Trusts of Philadelphia for his researches in radioactivity and X-rays. This award is made annually for scientific achievement in accordance with the terms of a bequest over a century ago by John Scott. The award the previous year had been made to Madame Curie. In 1923 he received the Leonard prize of the American Roentgen Ray Society for work done in 1922. This was a competitive prize, awarded for work presented anonymously to the judges. In 1923 he received the Comstock Prize of the National Academy of Sciences, a prize awarded

every five years for discovery or investigations in electricity, magnetism, or radiant energy.

He was awarded the honorary Sc.D. degree by the University of Pennsylvania in 1922 and by the University of Colorado in 1923.

He was a member of the National Academy of Sciences, the Philosophical Society, the American Academy of Arts and Sciences, the American Physical Society, the American Association for the Advancement of Science, Société de Physique, Radiological Society, Roentgen Ray Society, American Society for Cancer Research, Phi Beta Kappa, Sigma Xi, and of the Society of the Descendants of the Signers of the Declaration of Independence.

For many years before his death Duane was a sufferer from diabetes, which progressed with continually increasing intensity, making necessary the constant administration of insulin, and imposing continually increasingly severe restrictions on his activity. As early as 1927 his sight was so impaired that his scientific reading was seriously restricted, and from this time on much of his reading and writing had to be done through his secretary. In 1931 he suffered a paralytic shock, which totally incapacitated him for some months. From this he slowly recovered, and was able to resume productivity. His active work practically terminated in the fall of 1933, when he was given a year's leave of absence. In the fall of 1934 he retired with the title of Professor of Bio-Physics Emeritus. He spent the last months of his life at his home in Devon, Pennsylvania. Here he died on March 7, 1935, weakened by the continual progress of the diabetes, but the immediate cause of his death was a second paralytic stroke. In spite of the fact that toward the end his physical incapacity was almost complete, he continued his scientific work with mental alertness, enthusiasm and courage. In fact, his courage and uncomplaining cheerfulness during the whole course of his illness was an inspiration and a wonder to all who knew him.

Duane, at as early an age as four years, manifested a keen interest in mechanical matters which foreshadowed his later

physical interests. His most noticeable personal characteristic was the quietness and modesty of his manner. He never seemed excited or hurried, but was nevertheless certain of his own mind. In spite of his quietness, in committee meetings he managed in his own way to give weight to his opinions, which always were of an admirable sanity. His tastes were pronouncedly musical and he was a competent performer, not only on the piano, but on the organ. A favorite recreation was bridge whist with his friends at the Somerset Club in Boston.

Duane's contributions as a member of the Cancer Commission of Harvard University were most important in introducing clarity and precision into a subject which, when he took hold of it, had realized few of its own possibilities. Of his published papers, eight, presented mostly in medical journals, deal with technical matters pertaining to the application of radioactive materials and of X-rays in the treatment of cancer. Doubtless Duane's most important contribution in this field was in working out the technical details of the method of measuring X-ray dosage in terms of the ionization of air. Not only did he work out the details, but he was largely influential in securing, first its official adoption in this country, and then its international adoption at the Stockholm Congress in 1928. Further, the technical details of the method of collecting radon, purifying it and mounting it in "applicators" for transfer to the affected location in the patient were largely of Duane's devising. In the early years of his connection with the Cancer Commission, Duane personally made the radium applications to the patients, but later turned this phase of the work over to others.

There can be no question, however, but that Duane's chief claim to scientific eminence rests on his work done in the Jefferson Laboratory after 1914, much of it in collaboration with a number of pupils, candidates for the Ph.D. degree under his direction. Probably the most important single piece of work was done very early in his career at the Jefferson Laboratory. At the Washington meeting of the American Physical Society in April, 1915, Duane and Hunt announced the celebrated

"Duane-Hunt law." This law states that there is a sharp upper limit to the X-ray frequencies emitted from a target stimulated by the impact of electrons, and that this frequency is given by the quantum connection, independently of the material of the target, $h\nu = eV$, where ν is the maximum frequency of the emitted radiation, and V the total difference of potential through which the exciting electrons have fallen. This discovery had been foreshadowed in the announcement by Duane at the Philadelphia meeting in December, 1914, that the effective wave length of the total X radiation (that is, roughly, its center of gravity) satisfies the quantum relation within a factor of less than 2. Of this law the Handbuch der Experimental Physik remarks, "The significance of the Duane-Hunt law for Roentgen spectroscopy cannot be overestimated." It has been abundantly checked since then by other experimenters. Duane's physical intuition convinced him that his law could be used inversely as a more accurate method of determining Planck's h, or more strictly h/e, than any hitherto used, and in 1917 he determined with Blake as the most probable value of h, 6.555×10^{-27}, as contrasted with 6.41, the accepted value when he published his law. Important improvements in the technique of the ionization chamber were made in connection with these measurements. Finally, in 1921, he found with Palmer and Yeh the value $6.556 \pm 0.009 \times 10^{-27}$, as against the value 6.542 ± 0.008, estimated by Birge in 1932 as the best mean from all sources. In February, 1936, Birge in reviewing the entire situation with respect to the fundamental physical constants states that of the six known methods of determining h/e, by far the most accurate is the method of determining the Duane-Hunt limit of the continuous spectrum.

In 1919, Duane and Shimizu, among others, were instrumental in establishing that there is no "J" radiation, of frequency greater than the K series, a subject about which there was considerable discussion at that time. Their method of attack was by absorption measurements on aluminum. Also in 1919, Duane and Shimizu first established that the total X-ray intensity produced by cathode rays of given intensity is propor-

tional to the ordinal number of the element composing the target, not to its atomic weight. The proof was given by observations of targets of iron, nickel, cobalt, and copper.

In 1920, Duane and Patterson found that the angles of reflected X-rays from crystals deviated by small amounts from what would be calculated by the simple Bragg reflection formula. The explanation was found in the partial penetration of the X-rays into the body of the crystal and a deviation from unity of the index of refraction of the crystal for X-rays. From their measurements they deduced a value for the index of refraction of the crystal for X-rays close to the value now accepted. This phenomenon had been previously observed qualitatively by Stenström, and the explanation suggested. Also in 1920, Duane and Patterson with the aid of improved apparatus of improved resolving power, split the β_1 line of molybdenum into two components.

In 1921, Duane, Palmer and Yeh, in the same paper already referred to, giving a more accurate value of h, found that there is no difference within one part in 2000 between the apparent limit of the spectrum for rays leaving the target at 90° and 45°, a fact which they expressed by saying that there is no Doppler effect of this magnitude.

During the years 1919-22 Duane and his pupils were especially active in making precision measurements of many characteristic X-ray radiations, from which they were able to establish the same sort of series relations that are known to be valid in the visible spectrum, and in measuring the X-ray absorption in various metals, for which they were able to establish definite formulas. In 1922, Duane established in collaboration with his son Arthur that the intensity of scattered X radiation goes rapidly to zero as the angle of incidence goes to zero, and in particular, the intensity of the radiation excited by 29.35 volt electrons is zero at all angles of scattering less than 9.7°. In 1922, Duane with Clark suggested an interesting modification in the Laue method of crystal analysis, in which the maximum frequency of each spot of the Laue pattern was measured independently by an ionization method.

In 1923, he made the interesting discovery that in some cases there is a certain extra radiation emitted from a crystal besides that to be expected by the Bragg law. This was correctly explained in terms of the excitation of the characteristic frequency of some of the atoms of the crystal by the analyzing X-rays. Also in 1923, Duane, by an interesting application of the more extreme form of quantum theory, obtained a very much simplified deduction of the Bragg law of reflection of X-rays from a crystal. The frequency entering into the quantum relation was found in the periodic repetition in space of the structure of the crystal, a novel and a fruitful point of view.

In 1924 and 25, Duane and several collaborators published a number of papers dealing with the recently discovered Compton effect, which consists in a shift in the wave length of X-rays scattered by impact on electrons. At first Duane was not able to verify the existence of the effect, but in its place found another effect, sometimes referred to in the literature of that time as the "Duane" effect. He thus became involved in a controversy with Compton which was later settled to the advantage of the latter, and not without some damage to Duane's reputation. It would seem that this episode has enough importance for the history of physics to justify recording it in a little more detail. What Duane found was a scattered radiation of altered wave length, but the alteration in wave length was not that demanded by Compton's formula, and furthermore it apparently exhibited a correlation with the scattering substance, instead of being independent of it. This led Duane to explain the scattering in terms of a "tertiary" effect. It was supposed that the incident X-rays liberated electrons by a photo-electric action, and these electrons, impinging on other atoms, in turn gave rise to X-radiation, which played the role of the scattered radiation. The loss of frequency by the scattered radiation was correlated with the loss of energy of the photo-electrons in the body of the scattering substance. Duane and Compton both made the most earnest efforts to find the reason for the lack of agreement. Compton visited Duane's laboratory, and with Duane's apparatus was able to get only

the same results as Duane. At the summer meeting of the British Association at Toronto in 1924 both Duane and Compton presented their own accounts, each so convincingly that the reporter of the meeting in *Nature* was led to remark, "At the time of the meeting each observer appeared to have almost overwhelming evidence in favor of his point of view, and had the audience had to listen to only one side—either side would have done equally well—it would probably have been convinced as to the accuracy and soundness of the views advanced." The explanation proved to involve a curious combination of experimental error and fortuitous coincidence. Duane's X-rays were probably not intense enough, the beam was too broad, there was too much scattered radiation from other parts of the apparatus, and in at least one case there was a spurious effect due to accidental impurity in the metal of the target. Once convinced of the true state of affairs, Duane was most generous in his admission of error, and the unreservedness of his announcement of his change of position at a meeting of the Physical Society must remain a pleasant memory to all who heard it. Later, Duane and Allison made one of the most accurate measurements of the Compton shift. At the same time, it would appear that even yet the subject is not completely cleared up. Duane and Allison found that the width of the line of characteristic molybdenum radiation scattered by lithium was too great to be accounted for by the Compton effect, and Compton has confirmed this observation. The explanation of this too great width appears not yet to have been given. At least one of Duane's collaborators, who was intimately associated with the work, is still convinced that the "tertiary" effect exists, and the necessity for a similar tertiary effect in million volt radiation has lately been recognized.

Other important results date from the same period. In 1925, Duane and Allison checked with much greater precision the conclusion of M. de Broglie, reached in 1914, that the characteristic frequency of any substance is the same whether excited by electron bombardment or by incident X-rays. Duane and Allison also showed in 1925 that if K radiation appears

in the secondary spectrum of silver the exciting radiation must contain frequencies at least as high as those of the K radiation itself. In 1925, Duane resurrected an idea originally suggested by Bragg a number of years before, and showed how to get the electron distribution in a crystal from a Fourier analysis of the intensity of the reflected X-ray pattern, putting the method into a form conveniently suitable for calculation. The method was immediately applied to NaCl with interesting results by Havighurst, who was able to give a definite proof that all the 100 planes are equivalent, whereas the 111 planes alternate. The method of Fourier analysis has now come to play an indispensable part in the analysis of complicated crystals.

The end of the year 1925 marks an abrupt diminution in Duane's productivity. In 1926 he took his first sabbatical leave, being largely forced thereto by considerations of health. On his return he investigated the excitation of X-rays in a target consisting of mercury vapor, and was able to establish that the yield of X-rays in terms of the potential drop of the exciting cathode rays is not markedly different from that found in solid targets. At the New York meeting of the American Physical Society he presented, with Hudson, a study of the variation with direction of the intensity of radiation excited in mercury vapor, finding that the radiation emitted at an angle of 45° with the impinging electron stream is about twice as intense as that emitted at 135° a conclusion in agreement with that of other observers for emission from solids.

Duane's last three papers were published early in 1932. At that time he was constructing an improved photometer for the greater resolution of characteristic X-radiation, and determining new lines in the K series of various elements with the aid of the greater resolving power.

All these accomplishments, the enduring importance of which in the permanent achievements of the physics of X-rays is too obvious for further elaboration, were made under physical difficulties that would have stopped a less resolute and devoted man. Not only was there the handicap of his own physical

disabilities, but in the latter part of his life there was the sadness from his son's tragic death, a shock which seemed to overtax his elasticity and from which he recovered only slowly. His persistence of purpose and his winsomeness of spirit remain a cherished memory to those who knew him.

BIBLIOGRAPHY

1895

Velocity of Electric Waves on Wires. (With J. Trowbridge.) Amer. Journ. Sci., 49, p. 297.

1896

Ueber eine dämpfende Wirkung des magnetischen Feldes auf rotierende Isolatoren. Annalen der Physik, 58, p. 517.

1897

Ueber die dämpfende Wirkung des magnetischen Feldes auf rotierende Isolatoren. (With W. Stewart.) Annalen der Physik, 61, p. 436.

Ueber eine magnetische Methode metallisches Eisen nach zu weisen. Annalen der Physik, 62, p. 543.

1898

Ueber electrolytische Thermoketten. Annalen der Physik, 65, p. 374.

1900

An Electric Thermostat. (With C. A. Lory.) Amer. Journ. Sci., 9, p. 179, March.

1901

On the Velocity of Chemical Reactions. Amer. Journ. Sci., 11, p. 349, May.

The Absolute Measurement of Self-Inductance. Phys. Rev., 13, p. 250, October.

Note on Electrometers. Phys. Rev., 13, p. 369, December.

1902

On the Siphon. Science, 15, pp. 152-153.

On the Boundary Conditions of the Electric Field. Phys. Rev., 14, p. 149, March.

A Device for Synchronizing Motors. Elec. Rev. (New York), 40, p. 357, March 15.

1904

On the Differential Telephone. (With C. A. Lory.) Phys. Rev., 18, p. 275, April.

1905

Radioactivité:—Sur l'ionization produite entre les plateaux paralleles par l'émanation du radium. Comptes Rendus, 140, p. 786, March 20.

1906

Emission of Electricity from the Radium Products. Science, 24, p. 48, July 13.

1908

Radioactivité:—Le parcours des rayons α. Comptes Rendus, 146, p. 958, May 11.

Radioactivité:—Sur les rayons secondaires des rayons α. Comptes Rendus, 146, p. 1088, May 25.

On the Emission of Electricity from the Induced Activity of Radium. Amer. Journ. Sci., 26, p. 1, July.

1909

Ueber den Wirkungsbereich der α-Strahlen. Annalen der Physik, 28, p. 443.

Radioactivité:—Le dégagement de chaleur des corps radioactifs. Comptes Rendus, June 1.

Radioactivité:—La chaleur de polonium. Comptes Rendus, June 21.

1910

Radioactivité:—Sur les mesures quantitative de l'émanation du radium. (With A. Laborde.) Comptes Rendus, 150, p. 1421, May 30.

Sur une méthode photographique d'enregistrement des particules α. Le Radium, July.

Radioactivité:—Sur le dégagement de chaleur dans un mélange de radium et d'un sel phosphorescent. Comptes Rendus, August 1.

Radioactivité:—Sur l'énergie des rayons du radium. Comptes Rendus, August 16.

1911

On the Heat Generated by Radio-Active Substances. Amer. Journ. Sci., 31, April.

Physique:—Sur la masse des ions gazeux. Comptes Rendus, 153, p. 336, July 31.

1912

Radioactivité:—Sur les charges electrique transportées par les rayons α et β. (With Jean Danysz.) Comptes Rendus, September 2.

The Effect of a Magnetic Field on Ionization Currents. Le Radium, 9, p. 342, October.

1913

The effect of a Magnetic Field on Ionization Currents. Amer. Journ. Sci., 35, p. 206, February.

Radioactivité:—Décomposition de l'eau par les rayons α. (With Otton Scheuer.) Comptes Rendus, February 10.

1915

On the Extraction and Purification of Radium Emanation. Phys. Rev., 5, no. 4, April.

Notes on the Atomic Nuclei. Phys. Rev., 5, no. 4, April.

On X-Ray Wave-Lengths. (With Franklin L. Hunt.) Phys. Rev., 6, no. 2, August.

1916

Planck's Radiation Formula Deduced from Hypotheses suggested by X-Ray Phenomena. Phys. Rev., 7, no. 1, January.

Radium in the Treatment of Cancer. Paper presented before the Second Pan-American Scientific Congress, Washington, D. C., December 27, 1915 to January 8, 1916.

A Chemically Active Modification of Hydrogen Produced by Alpha-Rays. (Abstract) (With G. L. Wendt.) Phys. Rev., 7, no. 6, June.

1917

A Reactive Modification of Hydrogen Produced by Alpha-Radiation. (With G. L. Wendt.) Phys. Rev., 10, no. 2, August.

Radiation and Matter. Science, 46, p. 1189, October.

The Value of "h" as Determined by Means of X-Rays. (With F. C. Blake.) Phys. Rev., 10, no. 6, December.

The Critical Absorption of some of the Chemical Elements for High-Frequency X-Rays. (With F. C. Blake.) Phys. Rev., 10, no. 6, December.

Methods of Preparing and Using Radioactive Substances in the Treatment of Malignant Disease and of Estimating Dosage. Boston Med. and Surg. Journ., 177, December 6.

1918

On the Relation between the K X-Ray Series and the Atomic Numbers of the Chemical Elements. (With Kang-Fuh Hu.) Phys. Rev., 11, no. 6, June.

1919

Are the Frequencies in the K Series of X-Rays the Highest Frequencies Characteristic of Chemical Elements? (With Takeo Shimizu.) Phys. Rev., 13, no. 4, April.

On the X-Ray Absorption Wave-Lengths of Lead Isotopes. (With Takeo Shimizu.) Proc. Nat. Acad. Sci., 5, p. 198, June.

On the Relation between the K Series and the L Series of X-Rays. (With Takeo Shimizu.) Phys. Rev., 14, no. 1, July.

On the Critical Absorption and Characteristic Emission X-ray Frequencies. (With Kang-Fuh Hu.) Phys. Rev., 14, no. 4, October.

On the Spectrum of X-Rays from an Aluminium Target. (With Takeo Shimizu.) Phys. Rev., 14, no. 5, November.

On the X-Ray Absorption Frequencies Characteristic of the Chemical Elements. (With Takeo Shimizu.) Phys. Rev., 14, no. 6, December.

On the X-Ray Absorption Frequencies Characteristic of the Chemical Elements. (With Kang-Fuh Hu.) Phys. Rev., 14, no. 6, December.

The Relation between the Intensity of the General X-Radiation and the Atomic Number of the Anti-Cathode. (With Takeo Shimizu.) Phys. Rev., 14, no. 6, December.

1920

On the K Series of X-Rays. (With Wilhelm Stenström.) Proc. Nat. Acad. Sci., 6, August.

Characteristic Absorption of X-Rays: L Series. (With R. A. Patterson.) Proc. Nat. Acad. Sci., 6, September.

On the Relative Positions and Intensities of Lines in X-Ray Spectra. (With R. A. Patterson.) Proc. Nat. Acad. Sci., 6, September.

The Absorption of X-Rays by Chemical Elements of High Atomic Numbers. (With Hugo Fricke and Wilhelm Stenström.) Proc. Nat. Acad. Sci., 6, October.

Data Relating to X-Ray Spectra. Bull. Nat. Res. Council, 1, November.

On the X-Ray Spectra of Tungsten. (With R. A. Patterson.) Phys. Rev., 16, no. 6, December.

1921

A Remeasurement of the Radiation Constant, "h," by Means of X-Rays. (With H. H. Palmer and Chi-Sun Yeh.) Journ. Optical Soc. Amer., 5, no. 3, May.

A Remeasurement of the Radiation Constant, "h," by Means of X-Rays. (With H. H. Palmer and Chi-Sun Yeh.) Proc. Nat. Acad. Sci., 7, August.

On the Calculation of the X-Ray Absorption Frequencies of the Chemical Elements. Proc. Nat. Acad. Sci., 7, September.

On the Calculation of the X-Ray Absorption Frequencies of the Chemical Elements. (Second Note.) Proc. Nat. Acad. Sci., 7, September.

1922

Absorption of Short X-Rays by Aluminium and Copper. (With K. C. Mazumder.) Proc. Nat. Acad. Sci., 8, March.

X-Ray Spectra Produced under Various Experimental Conditions. Journ. Radiology, March.

Roentgen Rays of Short Wave-Lengths and their Measurement. Amer. Journ. Roentgenology, 9, no. 3, March.

The Radio-Active Point of View. Proc. Amer. Philosophical Soc., 61, no. 4.

Note on X-Ray Spectra. (With R. A. Patterson.) Proc. Nat. Acad. Sci., 8, May.

A New Method of Using X-Rays in Crystal Analysis. (With George L. Clark.) Proc. Nat. Acad. Sci., 8, May.

The Production of Penetrating X-Rays. Amer. Journ. Roentgenology, 9, July.

Experiments on the Wavelengths of Scattered X-Rays. Phys. Rev., 3, September.

1923

The Reflection by a Crystal of X-Rays Characteristic of Chemical Elements in it. (With George L. Clark.) Proc. Nat. Acad. Sci., 9, April.

On the Abnormal Reflection of X-Rays by Crystals. (With George L. Clark.) Proc. Nat. Acad. Sci., 9, April.

The Transfer in Quanta of Radiation Momentum to Matter. Proc. Nat. Acad. Sci., 9, May.

Measurement of Dosage by Means of Ionization Chambers. Amer. Journ. Roentgenology and Radium Therapy, 10, no. 5, May.

A New Method of Crystal Analysis and the Reflection of Characteristic X-Rays. (With George L. Clark.) Journ. Optical Soc. Amer., 7, no. 6, June.

The Abnormal Reflection of X-Rays by Crystals. (With George L. Clark.) Science, 58, p. 1507, November.

The Wave-Lengths of Secondary X-Rays. (With George L. Clark.) Proc. Nat. Acad. Sci., 9, December.

The Wave-Lengths of Secondary X-Rays (Second Note). (With George L. Clark.) Proc. Nat. Acad. Sci., 9, December.

Ionization Methods of Measuring X-Ray Dosage. Amer. Journ. Roentgenology and Radium Therapy, 10, no. 12, December.

1924

On Tertiary X-Radiation, etc. (With George L. Clark.) Proc. Nat. Acad. Sci., 10, January.

Further Experiments upon the Reflection by a Crystal of its Characteristic X-Radiation. (With George L. Clark.) Proc. Nat. Acad. Sci., 10, January.

On Secondary and Tertiary X-Rays from Germanium, etc. (With George L. Clark.) Proc. Nat. Acad. Sci., 10, March.

The Secondary and Tertiary Rays from Chemical Elements of Small Atomic Number Due to Primary X-Rays from a Molybdenum Target. (With George L. Clark and W. W. Stifler.) Proc. Nat. Acad. Sci., 10, April.

On the Theory of the Tertiary Radiation Produced by Impacts of Photo-Electrons. (With George L. Clark.) Proc. Nat. Acad. Sci., 10, May.

Absorption Measurements of Certain Changes in the Average Wave-Length of Tertiary X-Rays. (With S. K. Allison.) Proc. Nat. Acad. Sci., 10, May.

Standard=ionisationskammer für Messungen der Röntgenstrahlendosis. (With Egon Lorenz.) Fortschritte auf dem Gebiete der Röntgenstrahlen, Band XXXVII, Heft 5.

The Reflection of Characteristic Bromine X-Radiation by a Crystal of Potassium Bromide. (With S. K. Allison.) Proc. Nat. Acad. Sci., 10, July.

The Influence on Secondary X-Ray Spectra of Placing the Tube and Radiator in a Box. (With S. K. Allison and George L. Clark.) Proc. Nat. Acad. Sci., 10, September.

The Influence on Secondary X-Ray Spectra of Placing the Tube and Radiator in a Box. (With Alice H. Armstrong and W. W. Stifler.) Proc. Nat. Acad. Sci., 10, September.

1925

On Scattered Radiation Due to X-Rays from Molybdenum and Tungsten Targets. (With S. K. Allison.) Proc. Nat. Acad. Sci., 11, January.

Note on the Quantum Theory of the Reflection of X-Rays. Proc. Nat. Acad. Sci., 11, March.

The Relative Intensities of Fluorescent and Scattered X-Rays. (With George L. Clark.) Proc. Nat. Acad. Sci., 11, March.

The Reflection of X-Rays by Alkali Halide Crystals. (With Alice H. Armstrong and R. J. Havighurst.) Proc. Nat. Acad. Sci., 11, April.

An Experimental Determination of the Critical Excitation Frequency for the Production of Fluorescent X-Radiation. (With S. K. Allison.) Proc. Nat. Acad. Sci., 11, August.

The Calculation of the X-Ray Diffracting Power at Points in a Crystal. Proc. Nat. Acad. Sci., 11, August.

Experiments on the Wave-Lengths of Scattered X-Rays. (With S. K. Allison.) Phys. Rev., 26, No. 3, September.

1926

On the Reflection by a Crystal of its Own Characteristic Radiation. Proc. Nat. Acad. Sci., 12, March.

1927

The Character of the General, or Continuous Spectrum Radiation. Proc. Nat. Acad. Sci., 13, September.

The Character of the General Radiation. Estratto Degli Atti Del Congresso Internazionale dei Fisici. September.
The General Radiation. Science, 66, December.

1928

The Standard Ionization Chamber for Roentgen Ray Dosage Measurements. (With Egon Lorenz.) Amer. Journ. Roentgenology and Radium Therapy, 19, no. 5, May.
The General X-Radiation from Mercury Vapor. Proc. Nat. Acad. Sci., 14, June.
The Measurement of Effective Wavelengths. (With J. C. Hudson and Helen N. Sterling.) Amer. Journ. Roentgenology and Radium Therapy, 20, September.

1929

On the Polarization of X-Radiation. Proc. Nat. Acad. Sci., 15, November.

1932

New Lines in the K Series of X-Rays. Proc. Nat. Acad. Sci., 18, January.
The Mass of the Electron. Proc. Nat. Acad. Sci., 18, April.
An Instrument for the Photometering of the New X-Ray Lines. Proc. Nat. Acad. Sci., 18, April.

Berthold Laufer

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OF

BERTHOLD LAUFER

1874–1934

BY

K. S. LATOURETTE

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BERTHOLD LAUFER
1874–1934

By K. S. Latourette

Berthold Laufer (Oct. 11, 1874–Sept. 13, 1934) spent most of the years of his maturity in the United States. He was, however, German-reared and educated and to the end preserved many of the attitudes and habits of the European savant. In him Europe made one of its most distinguished gifts to American scholarship. He was born in Cologne, the son of Max and Eugenie (Schlesinger) Laufer. His parents were wealthy and gave him every advantage of education and culture. A brother, Dr. Heinrich Laufer (died July 10, 1935), was an honored physician and for many years practised his profession in Cairo, Egypt.

As a child Berthold Laufer was much interested in dramatics, especially in marionettes. He and his brothers and sisters presented complete plays, all of them original. He himself wrote a number of them and they were usually given on his father's and mother's birthdays. He once cherished dreams of becoming a dramatist and throughout his life was an ardent admirer of Shakespeare. For years he studied music, especially the piano. He had a passion for the great masters and for the opera. Beethoven, Mozart, and Liszt were his favorites.

His father wished him to become a lawyer or a physician and predicted failure for him in his chosen profession of archeology. However, the senior Laufer became reconciled to his son's decision and assisted him in the prolonged and exacting preparation which the young man deemed necessary.

Life in the schools included a decade (1884-1893) in the Friedrich Wilhelms Gymnasium in Cologne. The years 1893-1895 were spent in the University of Berlin. During part of that time (1894-1895) work was taken in the Seminar for Oriental Languages in that city. The doctorate of philosophy was from the University of Leipzig in 1897. Laufer's doctoral dissertation, a critical analysis of a Tibetan text, was dedicated

"in love and loyalty to my parents on their silver wedding anniversary." Many years later, in 1931, in the city of his adoption, the University of Chicago appropriately added an honorary doctorate of laws.

Laufer decided on Eastern Asia as his special field and took the time to acquire the necessary linguistic and technical tools. He had courses in Persian, Sanskrit, Pâli, Malay, Chinese, Japanese, Manchu, Mongolian, Dravidian, and Tibetan. Among his teachers were some of the greatest scholars of the day. He studied Buddhism under Dr. Franke, Chinese under Professor Wilhelm Grube, Malay under the grammarian Gabelentz, Tibetan under Dr. Huth, and Japanese under Professor Lange.

In 1898, soon after publishing his doctoral dissertation, Laufer came to the United States. The step was taken at the suggestion of Professor F. Boas, himself German-born. Professor Boas obtained for his young fellow-countryman an invitation to the American Museum of Natural History in New York City. The move so made proved decisive. It was in the United States that Laufer henceforth made his home. Here he did the major part of his scholarly work. Here he married (Bertha Hampton), and here he died. Independent and self-reliant, after he came to the United States he no longer drew support from his parents, but made his own way financially.

Majoring as he did on the Far East, it was important that early in his career he should spend some time in that part of the world. In 1898-1899 he led the Jesup North Pacific Expedition to Saghalin and the Amur region to study the ethnology of the native tribes. The interest so developed and the information obtained are reflected in a number of articles from his pen and, indeed, in his studies throughout the rest of his life. In 1901-1904 he led the Jacob H. Schiff Expedition to China for research and investigation in cultural and historical questions and for the formation of ethnological collections.

Returning to the United States, Laufer became Assistant in Ethnology at the American Museum of Natural History, a position he held from 1904 to 1906. During part of this time, in 1905, he was lecturer in anthropology at Columbia

University and in 1906-1907 he was lecturer in anthropology and Eastern Asiatic languages in that same institution.

In 1908 Laufer went to the staff of the Field Museum of Natural History and there, in spite of repeated invitations to go elsewhere, sometimes at a marked increase in salary, he remained to the end of his days. Officially the positions held were successively Assistant Curator of the East Asiatic Division, Associate Curator of Asiatic Ethnology, and Curator of Anthropology.

Twice more Laufer made prolonged visits to the Far East, both times for scholarly purposes—in 1908-1910 as leader of the Blackstone Expedition to Tibet and China and in 1923 on the Marshall Field Expedition to China.

In the Field Museum Laufer's duties were multifarious. As Curator of Anthropology he had general oversight of new accessions and of the installation, labeling, and cataloging of materials, and upon him fell the direction of his staff. His chief interest, naturally, was in the Chinese exhibits. Most of these were composed of purchases made during his expeditions to the Far East. His especial pride was the jade collection and he preferred always to show it in person to visitors. He considered it and his monograph on jade as among his major contributions. At the time of his death he had just finished a completely new installation of the entire Chinese Collection. As will be seen from a glance through his bibliography, Laufer edited many of the Museum's publications and actually wrote many of them with his own pen. He was a prodigious worker. Famous in the Museum's staff were his two desks, both piled high with accumulated tasks, and with a swivel chair between them so that he could turn from one to the other.

To his heavy burdens on the staff of the Field Museum, Laufer willingly added many others. There was the constant stream of visitors, some of them distinguished scholars, others Chinese students, and still others youthful beginners in Far Eastern subjects. He was enthusiastic in encouraging Chinese students in scholarly investigations of their own culture.

Through his later years he was easily the outstanding American sinologist. To him, then, came for advice and criticism many who aspired to a career in that field. To these embryonic scholars he gave unstintedly of his time. Thoroughly frank in his criticism and in pointing out defects in their work, he was also extraordinarily kind and often went through their manuscripts with minute care, suggesting corrections and additions. He was severe in his condemnation of carelessness, incompetence, or superficiality. Accordingly, his praise, when given—as it often was—became an especially high reward.

Laufer was deeply concerned in promoting an increased interest in the United States in the serious study of Far Eastern cultures. He gathered extensive collections of Chinese books and manuscripts for the Newberry and the John Crerar Libraries in Chicago. One work from the Newberry Library, transferred in 1928 to the Library of Congress, contains the lost Sung (1210 A.D.) *Kêng Chih T'u*, of which no other copy is known. He collaborated with the United States Department of Agriculture in its researches in Far Eastern plants and agricultural methods. When the American Council of Learned Societies formed its Committees on the Promotion of Chinese and Japanese Studies he accepted membership on both. He was the first chairman of the Committee on the Promotion of Chinese Studies and brought to the task creative imagination, and an enthusiasm which led him to devote to it an amazing amount of energy and time. To the leadership which he gave in the initial stages of these Committees must be ascribed much of the remarkable progress which Far Eastern studies have made in the United States in the past decade.

The list of committees and scholarly societies to which Laufer belonged is impressive. He seemed to welcome invitations to help with whatever appeared to him to give promise of promoting scholarship in the fields in which he was interested. It may have been a trace of the vanity which is to be found in most of us—a desire for recognition—or it may have been an urge to accomplish as much as possible, the lure of achievement. Whatever the reason, Laufer was forever taking on new

tasks and lengthening his list of membership in committees and societies. In several of these he took a very active part. He was a member of the Advisory Board of the China Institute of America; of the American Committee of the National Council of the Chinese Cultural and Economic Institute; of the Committee on the Promotion of Friendship between America and the Far East; of the board of the American Institute of Persian Art and Archaeology, a fellow of the Ethnological Society, a member of the American Association for the Advancement of Science; of the National Research Council; a member (as this biographical sketch attests) of the National Academy of Sciences, a distinguished member and at one time president of the American Oriental Society, honorary vice-president of the New Orient Society of America, a member and successively vice-president and president of the History of Science Society, a member of the American Anthropological Association, of the German Anthropological Society of Tokyo, of the North China Branch of the Royal Asiatic Society, of the Royal Asiatic Society, of the Société Asiatique, of the Hakluyt Society, of the American Folklore Society, of the Linguistic Society of America, of the Illinois Academy, of the Société de Linguistique, of the Société Finno-Ugrienne, of the Society of Friends of Asiatic Art, of the Society of East Asiatic Art (Berlin), of the Orientals (Chicago), and of the Barth Society (Vienna). He was a corresponding member of the Indian Research Society (Calcutta), an honorary member of the Archeological Society of Finland, and an honorary member and secretary of the American Friends of China (Chicago). He was associate editor of the American Journal of Archeology, a special correspondent of the National Library of Peiping, and a member of the Advisory Council of Yenching University.

To these many activities Laufer added an astonishing amount of writing. His hours were long, from nine to five in his office and evenings in writing or study at home. In one letter he speaks of his sixteen hour day. In his zest for work and with his high standards of accomplishment, often he assumed more than he could do. Partially finished manu-

scripts lay in his files for years, uncompleted. Highly sensitive and chronically overworked, at times, especially in his later years, he was unwell and subject to moods of depression. At times, too, ill-health and overwrought nerves made him irritable and extravagant in his censure of fellow scholars. Those who saw below the surface, however, readily forgave these idiosyncrasies, for they knew him to be the soul of loyalty and, when his feelings were touched, prodigal of his time and money. During the War of 1914-1918, for instance, though of German parentage, he gave generous financial assistance to the family of a French sinologist who had lost his life in the struggle.

From his labors Laufer found relief in his home life, in music, and especially in motoring. He was an excellent *raconteur*. His stories were usually drawn from Chinese sources and were always to the point. With his musical and artistic temperament, and with his mastery of Chinese, it was not strange that he found diversion in the rich stores of Chinese poetry. He enjoyed Chinese riddles and had an enormous collection of them which he hoped sometime to publish.

Scholar that he was, Laufer took great interest and pride in his personal library. On it he spent much of his salary. At his death it went, by letter of gift, to the Field Museum.

In the midst of his busy life, as we have said, Laufer took time to do an amazing volume of writing. As will be seen from the appended bibliography, his published works were over two hundred in number and ranged all the way from book reviews and articles of two or three pages to substantial monographs. Geographically these covered all of what used to be known as the Chinese Empire—China proper, Manchuria, Mongolia, Chinese Turkestan, and Tibet. They touched as well on Indian subjects, on Eastern Siberia, on Japan, Sakhalin, the Philippines, and the islands of the Pacific.

Yet within this wide geographical area Laufer's interests were fairly well defined. He did not attempt the impossible task of making himself an expert in all phases of Far Eastern life and culture. The record which we have summarized, the list of his society memberships, and his bibliography indicate

the range of his specialization. It was partly linguistic, partly artistic, to a less extent religious, but chiefly anthropological, and in the influence of one culture upon another. Laufer had little or no time for political history. Nor did he evince much concern over current political developments in the Far East, or spend many hours in studying the vast transformation wrought in our own day in the cultures of China and Japan. His interests were centered chiefly on these peoples as they were before the destructive irruption of the Occident. It was the understanding of the older phases of their culture which he sought to promote. After all, it was to archeology that he had early given his affections and it was the ancient life of mankind in the East of Asia which captured his imagination.

Languages were of interest to him mainly as tools. He knew and used an appalling number of them, some well and some only slightly. With the facility of one reared and educated on the Continent of Europe, he wrote in English, French, and German. He knew Chinese and Tibetan, and had some familiarity with Japanese and with several of the languages of India and of Central Asia. Much of his linguistic equipment was in fields in which not many other scholars, and especially American scholars, are proficient. Few, therefore, are competent to judge the entire range of his work.

While languages were to him chiefly means to an end, with his inquiring mind he could not fail to be fascinated by them for their own sakes. Among his writings, for instance, are a study of the genitive in the Altaic tongue, a long article on the prefix *a-* in Indo-Chinese languages, a small, privately printed brochure on the language of the Yüe-chi or Indo-Scythians, and what is really a major monograph on loan-words in Tibetan. He discussed, too, the origins of the Chinese and the Tibetan languages. He had brief notes on the derivation of our word "booze" and on Jurchi and Mongol numerals.

In the light of his love of music, it is not surprising that Laufer was deeply interested in Chinese art. Since so much of his study of the interchange of products, to be noted in a moment, had to do with examining the legends concerning the

results of the western journeys of Chang Ch'ien of the Han dynasty, it is not strange that the art of that period attracted him. One of his most important monographs was on the pottery of the Han dynasty. He had a shorter monograph on Chinese grave sculptures of the Han. He prepared a brochure on archaic Chinese bronzes of Shang, Chou, and Han times. He wrote a brief article on some newly discovered bas-reliefs of the Han.

Yet his interest in art ranged over other periods as well. Buddhist and Christian art in China won his attention. He had a long study of a landscape of Wang Wei, and he wrote on T'ang, Sung, and Yüan paintings. More than one art collector called on him to study his Chinese objects. As late as 1932 he identified in one collection four lost albums of pictures on the themes which were painted for K'ang Hsi in 1696 and then persuaded a patron of Chinese art to present them to the Library of Congress.

He had an interest in philosophy and religion. It is perhaps symptomatic of his emotional temperament that in later years he regretted having devoted so large a proportion of his time to the study of the rationalistic, coldly ethical, and politically and socially minded Confucianism at the expense of the more mystical *Tao Tê Ching* and Chuang Tzu. Not many of his writings dealt primarily with religion. On the great organized Chinese faiths he said little. Incidentally, however, he dealt extensively with Chinese popular religion, especially in some of its earlier forms and as it expressed itself in folklore and magic. So his studies in jade had a good deal to say of the use of that semi-precious stone in magic and religion. He wrote on the development of ancestral images in China and on totemic traces among the Indo-Chinese.

As a scholar, as we have suggested, Laufer was very much the anthropologist. It was in this field that a large proportion of his writing was done. He delighted in taking up specific human tools and practices and putting together all that could be discovered about them. Often the subjects studied were amusing, incidental, and curious rather than of very great prom-

inence. He seems here to have found a kind of diversion. Such were the tree-climbing fish, the domestication of the cormorant in China and Japan, the early history of polo, multiple births among the Chinese, finger-prints, the use of human skulls and bones in Tibet, what he called the pre-history of aviation and of television, certain recondite phases of sex, bird divination among the Tibetans, geophagy, the history of felt, coca and betel chewing, and insect musicians and cricket champions. Others had to do with objects or institutions of more obvious importance—such as the monograph on Chinese clay figures, which he called prolegomena on Chinese defensive armor. Such, too, were his studies of the reindeer and its domestication, and of ivory in China.

Probably Laufer's most important group of contributions lay within the realm of the influence of one culture upon another and of the migration of domesticated plants, of mechanical appliances, and of ideas from people to people. Especially did he devote himself to the interpenetration of cultures in Central and Far Eastern Asia. For this kind of study he was exceptionally well equipped. His knowledge of most of the more widely used languages of the area opened to him the literatures and the inscriptions of many of the peoples involved. His archeological and anthropological interest and training gave zest and background. His phenomenal memory made possible comparisons and put at his disposal a wide range of facts, many of them at first sight seemingly incidental.

In this field were written what some scholars consider his most important single monograph, *Sino-Iranica*. Here he described the migration of various specific cultivated plants. In most instances he traced the introduction of these to China and attempted to determine whether they came from Iran or from some other land. He also included some minerals, metals, drugs, textiles, and precious stones. For some he traced not only the migration to China but also contributions of China to Iran. In appendices he discussed Iranian elements in Mongol, Chinese elements in Turki, and Indian elements in Persian. In this single monograph he used various languages of the Far

East and of Central Asia, employed Arabic sources, and evinced a knowledge of the pertinent literature in several languages of western Europe.

Again and again in articles and monographs Laufer dealt with phases of this major theme. His great work on jade included not only China but references to the use of the semi-precious stone in other lands. He was interested in the possible spread of culture features and artifacts from the Amur region into other parts of the Far East and to the Americas. He wrote on the wide extension of amber, on the bird-chariot in China and Europe, on the introduction of maize into Eastern Asia, on the Jonah legend in India, on the cycle of the twelve animals (so familiar in the Far East), on an ancient Turkish rug, on Christian art in China, on the coming of vaccination to the Far East, on Chinese pottery in the Philippines, on Arabic and Chinese trade in walrus and narwhal ivory, on the story of the pinna and the Syrian lamb, on burning-lenses in China and India, on asbestos, salamander, and the diamond, on Chinese and Hellenistic folklore, on the coming of tobacco to Asia, Europe, and Africa, and its use there, on the history of ink in China, Japan, Central Asia, India, Egypt, Palestine, Greece, and Italy, on the migration of American plants, and on the lemon in China and elsewhere. It was characteristic of him that one of his longest and most careful reviews was of T. F. Carter, *The Invention of Printing in China,* in which was discussed the migration of paper from China to Europe and the possible debt of Europe to China for the art of printing.

Laufer published so voluminously partly because he relied extensively upon the prodigious Chinese literature and upon what Chinese scholars had written through the ages. Chinese savants had done the spade work and he made their results available to the Occident. This does not mean that he borrowed without giving credit where credit was due. In his scholarly writings where this did not seem pedantry, he was meticulous in his references to his sources. Moreover, of direct, pedestrian, full-length translation he did very little. In his earlier years, when he was trying out his tools, he published

a few translations, perhaps partly as self-imposed literary exercises. Later he did little of this kind of translation. Nor were his writings summaries and popularizations in Western languages of the labors of Far Eastern scholars. He employed treatises in Asiatic languages as he used those of the Occident, critically and as mines of information from which came the many facts which he assembled, especially in his descriptions of objects in the various collections which he gathered or utilized, and in tracing the spread of a given custom, plant, or commodity. In a certain sense his great service was one of synthesis, the comparison and interpretation of existing knowledge. In this he made a distinct contribution to scholarship. Relatively few men, either of the Occident or the Orient, have been equipped in so many of the languages of Central and Eastern Asia. To most Occidental scholars the treasures locked in these languages are as though they were not. His was the function of unsealing them and from the rich stores so disclosed to bring forth and to piece together information in such fashion as to show the interrelation of cultures and the contribution of one to the other.

Of what is usually called generalization Laufer did but little. He wrote few articles attempting to set forth the main outlines of Chinese culture. Once in a long while he attempted it. His brief article on "Some Fundamental Ideas of Chinese Culture" (*Journal of Race Development,* Vol. V, Oct., 1914, pp. 160-174) was one of the few of these efforts. An able younger American sinologist declares that he has found it among the most helpful of Laufer's writings, and states that he is carrying out his own research largely on the basis of the ideas there set forth.

In most of his more serious work Laufer wrote with scholarly objectivity. In it he did not allow his emotions, always strong, or his prejudices, sometimes acute, to enter. Only in infrequent lighter articles did his personal idiosyncracies become obvious. He disciplined himself to observe the same high standards of scientific accuracy by which he measured others.

It would be too much to expect infallibility of Laufer. He

would have been the first to insist that his writings must be judged primarily not by their finality but by their assistance to other scholars in expanding the borders of human knowledge. Honest, able work on which others could build and build so well that they could discover in it the flaws of which he could not be aware was probably what he would most desire.

That some of his publications are being criticized by younger scholars who have found them useful is to be expected. Thus it is said that of the two Chinese works on which he leaned heavily in his important monograph on jade, one is very faulty. In a recent number of the *Zapiski* of the Russian Institute of Oriental Studies, N. N. Poppe, writing on *Problems in Buriat Mongol Literary History*, points out what he believes to be deficiencies in Laufer's *Skizze der mongolischen Literatur* (*Revue orientale*, Vol. VIII, 1907, pp. 165-261). Another Russian has recently endeavored to refute something of what Laufer said about the Giliaks. A younger Chinese scholar has recently asserted that in his discussion of the introduction of spectacles to China, Laufer was misled by mistakes in the Chinese sources upon which he relied. (See Ch'iu K'ai-ming, *The Introduction of Spectacles into China*, in *Harvard Journal of Asiatic Studies*, Vol. 1, July, 1936, pp. 186-193.) Yet it must be said at once that the work of few if any scholars escape this fate. It must also be added that Laufer was engaged in a revision of his *Jade* which, unhappily, was left unfinished by his untimely death.

In a certain sense Laufer was never completely adjusted to his American environment. In one important respect—in his interest and achievements in anthropology and in the field of culture contacts—he was at home in the atmosphere of American scholarship. Because of the American interest in the social sciences, Laufer could here find congenial spirits who could talk with him as equals and by whom he could be helped. However, in some other ways he remained an alien. In a letter written in his later years he declined to preside at an important meeting on the ground that "a Yank" could do it better. He was, to be sure, loyal to the land of his adoption. However, in East Asiatic studies he stood alone and must often have felt

his isolation. This was partly because, until very recently, the United States has had so few experts in that field. Significantly, however, another element entered. Most Americans who specialize in the Far East do so with the purpose of understanding the current situation in that part of the world. They realize that the United States faces the East of Asia across a rapidly narrowing ocean and must be prepared to deal with its peoples successfully and, if possible, amicably. If they are not to make tragic blunders, Americans, so these scholars hold, must understand these peoples and to do so must know their history and culture. American specialists give themselves to Far Eastern studies, partly because they become interested in them for their own sake, but chiefly from the utilitarian purpose of making their country at home in an age in which it must live on terms of intimacy with Eastern Asia. The Far Eastern scholarship of the United States has tended to devote itself to diplomatic and commercial relations, to economic problems, to contacts between the Far Orient and the Occident, and to current changes in the cultures of the Far East.

The most distinguished European savants who have majored in the Far East, on the other hand, have devoted themselves almost exclusively to the older history and cultures of this region. They have not really understood the current situation. Nor have they cared to do so. That the results of their scholarship should be useful in facilitating the intercourse between the West and the East has seemed to them to threaten its objectivity.

In that European atmosphere Laufer received his training and he could never quite adjust himself to the American outlook nor free himself of a certain impatient disdain for it. This attitude was reënforced by the fact that during most of his life America had no sinologists who could begin to equal him in his acquaintance with the languages and in his prodigious learning in the pre-nineteenth century culture. However, in at least his later years Laufer came to see that in dealing with the Far East the United States must develop its own particular type of scholarship adapted to its interests and needs. He recognized that this might attain as high standards of scientific accuracy as had that of Europe. Indeed, he insisted that Amer-

ica must conform to its own patterns and not to those of Europe. Yet probably he never felt entirely reconciled to this phase of the intellectual climate of his adopted land.

Perhaps in this very maladjustment was Laufer's greatest contribution to American scholarship. By representing in the United States in so eminently worthy a fashion and for a generation this European tradition, he enriched American Far Eastern scholarship as he could not have done had he been completely in accord with it.

BIBLIOGRAPHICAL NOTE

The sources for the biographical sketch given above are many—partly the note, based on information given by Dr. Laufer, in *Who's Who in America, 1934-1935* (Vol. 18, p. 1417), partly information kindly provided by Mrs. Laufer and by a former associate and intimate friend, Miss Lucy Driscoll, partly material from Dr. Mortimer Graves of the American Council of Learned Societies, and to a less extent comments by various friends of Dr. Laufer, biographical notices which have appeared since Dr. Laufer's death, and the author's own personal acquaintance, never intimate, but of many years' standing. Among the more important articles on Dr. Laufer are the ones in the *American Anthropologist*, Vol. XXXVIII, pp. 101 ff., *Artibus Asiae*, Vol. IV, pp. 265-270, and *Monumenta Serica*, Vol. I, fasc. 2, pp. 487 ff.

The appended bibliography is the most nearly complete and accurate which has been published. It is based largely upon one compiled by Dr. Laufer himself and which appeared in the *Journal of the American Oriental Society*, Vol. LIV, pp. 352-362, but it has been checked with three other bibliographies and, where feasible, from the articles and monographs themselves. At least some of the inaccuracies appearing in other bibliographies have been eliminated and a number of titles have been discovered and added.

The photograph here reproduced comes through the courtesy of the Field Museum of Natural History.

BIBLIOGRAPHY OF BERTHOLD LAUFER, 1895-1934

Japanische Märchen (translated from the Japanese). *Cologne Gazette,* 1895, nos. 98, 120, 144.

Indisches Rezept zur Herstellung von Räucherwerk. Translated from the Tibetan with Tibetan text. *Verhandlungen der Berliner anthropologischen Gesellschaft,* July 18, 1896, pp. 394-398.

Zur Geschichte des Schminkens in Tibet. *Globus,* 1896, vol. LXX, no. 4, pp. 63-65.

Blumen, die unter den Tritten von Menschen hervorsprossen. *Der Urquell,* New Series, 1898, vol. II, part 3/4, pp. 86-88.

Eine verkürtze Version des Werkes von den hunderttausend Naga's. Ein Beitrag zur Kenntnis der tibetischen Volkereligion. Tibetan text, translation and introduction. Helsingfors, 1898. 129 pp. *Mémoires de la Société Finno-Ougrienne.*

Einige linguistische Bemerkungen zu Grabowsky's Giljakischen Studien. *Internationales Archiv für Ethnographie,* 1898, Vol. XI, pp. 19-23.

Fünf indische Fabeln aus dem Mongolischen. *Zeitschrift der deutschen morgenländischen Gesellschaft,* 1898, Vol. LII, pp. 283-288. Leipzig.

Neue Materialen und Studien zur buddhistischen Kunst. *Globus,* 1898, vol. LXXIII, No. 2, pp. 27-32. Illustrations.

Studien zur Sprachwissenschaft der Tibeter. *Sitzungsberichte des philos.-philol. und der histor. Classe der k. bayer. Akad. d. Wissenschaften,* München, 1898, part III, pp. 519-594.

Über eine Gattung mongolischer Volkslieder und ihre Verwandtschaft mit türkischen Liedern. *Der Urquell,* New Series, 1898, Vol. II, part 7/8, pp. 145-157.

Ethnological work on the island of Saghalin. *Science,* May 26, 1899, pp. 732-734.

Hohläxte der Japaner und der Südsee-Insulaner. *Globus,* 1899, Vol. 76, no. 2, p. 36.

Die angeblichen Urvölker von Yezo und Sachalin. *Centralblatt für Anthropologie,* 1900, no. 6, pp. 321-330.

Petroglyphs on the Amoor. *American Anthropologist,* N.S., 1899, Vol. I, pp. 746-750.

Preliminary notes on explorations among the Amoor tribes. *American Anthropologist,* N.S., April, 1900, Vol. II, pp. 297-338. Illustrations.

Beiträge zur Kenntnis der tibetischen Medizin. 2 parts. 90 pp. Leipzig, Otto Harrassowitz, 1900. In collaboration with Heinrich Laufer.

Ein Sühngedicht der Bonpo. Aus einer Handschrift der oxforder *Bodleiana. Denkschriften der kaiserlichen Akademie der Wissenschaften in Wien, phil.-hist. Classe,* Vol. XLVI, pp. 1-60. VII. Abhandlung.

Reviews of Grünwedel, *Mythologie des Buddhismus and S. Tajima's selected relics of Japanese art,* vols. I and II. *Globus,* 1900, Vol. LXXVIII, nos. 8 and 19, pp. 129, 310, 311.

Über das Va-Zur. Ein Beitrag zur Phonetik der tibetischen Sprache. *Wiener Zeitschrift für die Kunde des Morgenlandes.* Wien, 1898-99, Vol. XII, pp. 289-307; Vol. XIII, pp. 95-109, 199-226.

Felszeichnungen vom Ussuri. *Globus,* 1901, Vol. LXXIX, no. 5, pp. 69-72.

Review of H. Francke's *Der Frülingsmythus der Kesarsage, ein Beitrag zur Kenntnis der vorbuddhistischen Religion Tibets;* and of his *Ladakhi Songs. Wiener Zeitschrift für die Kunde der Morgenlandes,* 1901, Vol. XV, pp. 77-107.

The Decorative Art of the Amur Tribes. *Jesup Expedition Publications, American Museum Memoirs, New York,* Vol. VII, 1902, 86 pp. 4°. 33 plates.

Über ein tibetisches Geschichtswerk der Bonpo. *T'oung Pao,* 2nd Series, Leiden, 1901, Vol. II, no. 1, pp. 24-44.

Zum Märchen von der Tiersprache. *Revue Orientale (Keleti Szemle),* Budapest, 1901, Vol. II, no. 1, pp. 45-52.

Zur Entstehung des Genitivs in den altaischen Sprachen. *Revue Orientale (Keleti Szemle),* Budapest, 1901, Vol. II, no. 2, pp. 133-138.

Verzeichnis der tibetischen Handschriften der königlichen Biblothek zu Dresden. *Zeitschrift der deutschen morgenländischen Gesellschaft.* 1901, Vol. LV, pp. 99-123.

Zwei Legenden des Milaraspa. Translated from the Tibetan, with Tibetan text. *Archiv für Religionswissenschaft,* Tübingen u. Leipzig, 1901, Vol. IV, pp. 1-44.

Aus den Geschichten und Liedern des Milaraspa. Translated from the Tibetan, with Tibetan text. *Denkschriften der kaiserlichen Akademie der Wissenschaften in Wien, phil.-hist. Classe,* 1902, Vol. XLVIII, II. Abhandlung, pp. 1-62.

Mitteilung über die angebliche Kenntnis der Luftschiffahrt bei den alten Chinesen. *Ostasiatischer Lloyd,* Vol. XVII; s. *Orient Bibl.,* 1904, no. 1489, p. 78.

Review of Jul. Lessing, *Chinesische Bronzegefässe. T'oung Pao,* 2d Series, Vol. IV, pp. 264-267; s. *Orient Bibl.,* 1904, no. 1583, pp. 82.

Religiöse Toleranz in China. *Globus,* 1904, Vol. LXXXVI, pp. 219, 220.

Ein buddhistisches Pilgerbild. *Globus,* 1904, Vol. LXXXVI, pp. 386-388.

Zur Geschichte der chinesischen Juden. *Globus,* 1905, Vol. LXXXVII, no. 14, pp. 245-247.

Chinesische Altertümer in der römischen Epoche der Rheinlande. *Globus,* 1905, Vol. LXXXVIII, No. 3, pp. 45-49.

Zum Bildnis des Pilgers Hsüan Tsang. *Globus,* 1905, Vol. LXXXVIII, pp. 257, 258.

Ein angebliches Chinesisches Christusbild aus der T'ang Zeit. *Globus,* 1905, Vol. LXXXVIII, pp. 281-283. Illustrated.

Anneaux nasaux en Chine. *T'oung Pao,* 2d Series, Vol. VI, 1905, pp. 321-323.

Introduction to the book of W. Filchner, *Das Kloster Kumbum in Tibet.* Berlin, 1906, pp. ix-xiv.

Obituary notice of Dr. Georg Huth. *T'oung* Pao, 1906, pp. 702-706.

Historical jottings on amber in Asia. *Memoirs American Anthropological Association,* Vol. I, part 3, pp. 211-244.

The Bird-Chariot in China and Europe. *Boas Anniversary Volume,* pp. 410-424.

Editor, Boas anniversary volume. New York, G. E. Stechert & Co., 1906.

Ancient Chinese bronzes. *Craftsman,* April, Vol. XII, pp. 3-15. Illustrated.

A plea for the study of the history of medicine and natural sciences. *Science,* Vol. XXV, pp. 889-895.

The relations of the Chinese to the Philippine Islands. *Smithsonian Miscellaneous Collections,* Vol. L, part 2, Washington, 1907, pp. 248-284.

Zur Geschichte der Brille. *Mitteilungen des Ges. für Geschichte der Medizin,* Vol. VI, 1907, No. 4, pp. 379-385.

A theory of the origin of Chinese writing. *American Anthropologist,* Vol. IX, 1907, pp. 487-492.

Reviews of F. Karseh, *Forschungen über gleichgeschlechtliche Liebe. American Anthropologist,* vol. IX, pp. 390-397. W. v. Hoerschelmann. *Entwicklung der altchin. Ornamentik,* and H. Beckh, *Tib. Übersetzung Kalidasa's Meghaduta. Monist,* Vol. XVII, pp. 634-636.

W. W. Newell and the lyrics of Li-t'ai-po. *American Anthropologist,* Vol. IX, 1907, pp. 655, 656.

The introduction of maize into eastern Asia. *Congres internat. des Americanistes,* Quebec, Vol. I, 1907, pp. 223-257.

Note on the introduction of the groundnut into China. Ibid., 259-262.

Zur buddhistischen Litteratur der Uiguren. *T'oung Pao,* Ser. II, Vol. VIII, 1907, pp. 391-409.

Ein japanisches Frühlingsbild. *Anthropophyteia,* Vol. IV, 1 plate, pp. 279-284.

Skizze der mongolischen Literatur. *Revue orientale,* Vol. VIII, 1907, pp. 165-261. Russian translation published by the Academy of Sciences, Leningrad.

Origin of our dances of death. *Open Court,* vol. XXII, 1908, pp. 597-604.

Die Bru-ža Sprache und die historische Stellung des Padmasambhava. *T'oung Pao,* Vol. IX, 1908, pp. 1-46.

Die Sage von den goldgrabenden Ameisen. *T'oung Pao,* Vol. IX, 1908, pp. 429-452.

Skizze der manjurischen Literatur. *Revue orientale,* Vol. IX, 1908, pp. 1-53.

A Mongol irodalom vazlata. A Manszsu Irodalom Vazlata. Illustrated. Hungarian Translation of Sketch of Mongol and Manchu Literatures.

The Jonah legend in India. *Monist,* Vol. XVIII, 1908, pp. 576-578.

Chinese pigeon whistles. *Scientific American,* May, 1908, p. 394. Illustrated.

Chinese pottery of the Han Dynasty. Publication of the East Asiatic Committee of the American Museum of Natural History. Leyden, 1909. 75 plates and 35 figures.

Die Kanjur Ausgabe des Kaisers K'ang-Hsi. *Bulletin de l'Académie impériale des sciences de St. Pétersbourg,* pp. 567-574. St. Petersburg, 1909.

Der Cyclus der zwolf Tiere auf einem alt-turkistanischen Teppich. *T'oung Pao,* Vol. X, 1909, pp. 71-73 (avec note additionelle par E. Chavannes).

Ein homosexuelles Bild aus China (1 plate). *Anthropophyteia,* Vol. VI, 1909, pp. 162-166.

Kunst und Kultur Chinas im Zeitalter der Han. *Globus,* Vol. XCVI, 1909, pp. 7-9, 21-24.

Christian art in China (20 plates). *Mitteilungen des Seminars für orientalische Sprachen,* Vol. XIII, Berlin, 1910, pp. 100-118.

Die Ausnutzung sexueller Energie zu Arbeitsleistungen, eine Umfrage. *Anthropophyteia,* Vol. VII, 1910, pp. 295, 296.

Zur kulturhistorischen Stellung der chinesischen Provinz Shanshi. Beobachtungen auf einer Reise von Tai-yüan nach Hsi-an im Februar 1909. *Anthropos,* Vol. V, 1910, pp. 181-203.

Der Roman einer tibetischen Königin. Tibetischer Text und Übersetzung. 8 figures and book-ornaments after Tibetan designs drawn by Albert Grünwedel. Leipzig, Otto Harrassowitz, 1911. pp. x, 264.

Contributions to Paul Carus, *The fish as a mystic symbol in China and Japan. Open Court,* Vol. XXV, July, 1911, pp. 385-411. Illustrations and quotations from Laufer.

King Tsing, the author of the Nestorian inscription. *Open Court,* August, 1911, pp. 449-454.

The introduction of vaccination into the Far East. *Open Court,* Sept., 1911, pp. 525-531.

Chinese grave-sculptures of the Han period. 10 plates and 14 text-figures. New York, London, and Paris, 1911. 45 pp.

Modern Chinese collections in historical light. *American Museum Journal,* April, 1912, pp. 135-138. Illustrated.

The Chinese Madonna in the Field Museum (1 plate). *Open Court,* Vol. XXVI, Jan., 1912, pp. 1-6. Also as separate brochure.

Confucius and his portraits. *Open Court,* Vol. XXVI, March and April, 1912, pp. 147-168, 202-218 (1 plate and 25 text-figures). Also as separate book.

The discovery of a lost book. *T'oung Pao,* Vol. XIII, No. 1, 1912, pp. 97-106 (1 plate).

Five newly discovered bas-reliefs of the Han period. *T'oung Pao,* Vol. XIII, No. 1, 1912, pp. 107-112 (4 plates).

The Wang Chuan Tu, a landscape of Wang Wei. *Ostasiatische Zeitschrift,* Vol. I, No. 1, Berlin, 1912, pp. 28-55 (18 figures).

The name China. *T'oung Pao,* Vol. XIII, 1912, pp. 719-726.

Foreword to *Catalogue of a selection of art objects from the Freer Collection,* Washigton, 1912.

Jade, A study in Chinese archaeology and religion. 68 plates, 6 of which are colored, and 204 text-figures. *Field Museum Anthropological Series,* Vol. X, Chicago, 1912, 370 pp.

China can take care of herself. *Oriental Review,* Vol. II, 1912, pp. 595, 596.

The stanzas of Bharata. *Journal Royal Asiatic Society,* 1912, pp. 1070-1073.

Chinese Sarcophagi. *Ostasiatische Zeitschrift,* Vol. I, No. 3, Berlin, 1912, pp. 318-334. 5 illustrations.

Fish symbols in China. *Open Court,* Nov., 1912, pp. 673-680. Illustrated. (Reprinted from *Jade.*)

Postscript to Cole, *Chinese Pottery in the Philippines. Field Museum Anthropological Series,* vol XII, part 1, July, 1912, pp. 17-47.

The praying mantis in Chinese folk-lore. *Open Court,* No. 1, 1913, pp. 57-60. 3 illustrations. (Extract from *Jade.*)

The Chinese battle of the fishes. *Open Court,* No. 1, June, 1913, pp. 378-381. 1 illustration.

The development of ancestral images in China. *Journal Religious Psychology,* Vol. VI, 1913, pp. 111-123.

Dokumente der indischen Kunst. I. Heft. *Das Citralakshana nach d. tib. Tanjur herausgegeben und übersetzt.* Leipzig, Harrassowitz, 1913, 194 pp.

Descriptive account of the collection of Chinese, Tibetan, Mongol and Japanese books in the Newberry Library. Chicago, 1913. 4 illustrations.

Notes on turquois in the East. *Field Museum Anthropological Series,* Vol. XIII, No. 1, 1913, pp. 1-72. 6 plates (1 colored).

Arabic and Chinese trade in walrus and narwhal ivory. *T'oung Pao,* 1913, pp. 315-370, with addenda by P. Pelliot.

History of the fingerprint system. *Smithsonian Report for 1912,* pp. 631-652, Washington, 1913. (7 plates.)

In memorial of J. Pierpont Morgan. *Ostasiatische Zeitschrift,* Vol. II, 1913, pp. 222-225.

Epigraphische Denkmaler aus China. Teil I: *Lamaistische Klosterinschriften aus Peking, Jehol und Si-ngan* (with O. Franke). Berlin, 1914, fol. 81 plates, 2 portfolios.

The application of the Tibetan sexagenary cycle. *T'oung Pao,* Vol. XIV, 1913, pp. 569-596.

Der Pfau in Babylonien. *Orientalistische Literaturzeitung,* No. 12, 1913, col. 539, 540.

Catalogue of a collection of ancient Chinese snuff-bottles in the possession of Mrs. George T. Smith. Chicago, privately printed, 1913, 64 pp.

Über den Wert chinesicher Papierabklatsche. *Ostasiatische Zeitschrift,* Vol. II, 1913, pp. 346, 347.

Bird divination among the Tibetans (Notes on Document Pelliot, no. 3530, with a study of Tibetan phonology of the ninth century). *T'oung Pao,* Vol. XV, 1914, pp. 1-110. Leyden, E. J. Brill, 1914.

Discussion on relation of archaeology to ethnology. *American Anthropologist,* Vol. XV, Oct.-Dec., 1913, pp. 573-577.

Was Odoric of Pordenone ever in Tibet? *T'oung Pao,* 1914, pp. 405-418.

Obituary notice of F. H. Chalfant. *T'oung Pao,* 1914, pp. 165, 166.

The sexagenary cycle. Once more. *T'oung Pao,* 1914, pp. 278, 279.

Chinese clay figures. Part I. Prolegomena on Chinese Defensive Armor. 64 plates and 55 text-figures. *Field Museum Anthropological Series,* Vol. XIII, No. 2, 1914, pp. 73-315.

Review of H. Beckh, *Verzeichnis der tibetischen Handschriften. Journal Royal Asiatic Society,* Oct., 1914, pp. 1124-1139.

Some fundamental ideas of Chinese culture. *Journal Race Development,* Vol. V, Oct., 1914, pp. 160-174.

The story of the Pinna and the Syrian Lamb. *Journal American Folklore,* Vol. XXVIII, April-June, 1915, pp. 103-128.

The Eskimo screw as a culture-historical problem. *American Anthropologist,* Vol. XVII, 1915, pp. 396-406.

The Prefix A- in the Indo-Chinese languages. *Journal Royal Asiatic Society,* Oct., 1915, pp. 757-780.

Karajang. *Journal Royal Asiatic Society,* Oct., 1915, pp. 781-784.

Optical lenses. I. *Burning-Lenses in China and India. T'oung Pao,* 1915, pp. 169-228.

Burning-lenses in India. *T'oung Pao,* 1915, pp. 562, 563.

Three Tokharian bagatelles. *T'oung Pao,* 1915, pp. 272-281.

Vidanga and cubebs. *T'oung Pao,* 1915, pp. 282-288.

W. W. Rockhill (Obituary Notice). *T'oung Pao,* 1915, pp. 289, 290.

Asbestos and Salamander. An essay in Chinese and Hellenistic Folk-lore. *T'oung Pao,* 1915, pp. 299-373.

Chinese transcriptions of Tibetan names. *T'oung Pao,* 1915, pp. 420-424.

The Diamond. A study in Chinese and Hellenistic Folk-lore. *Field Museum Anthropological Series,* Vol. XV, 1915, No. 1, pp. 1-75.

Two Chinese imperial jades. *Fine Arts Journal,* Chicago, Vol. XXXII, June, 1915, pp. 237-241. 4 illustrations.

The Nichols Mo-So Manuscript. *Geographical Review,* Vol. I, April, 1916, pp. 274-285. 4 figures.

Ethnographische Sagen der Chinesen. *Festschrift Kuhn* (München), 1916, pp. 198-210.

Chinesische Schattenspiele, übersetzt von Wilhelm Grube, herausgegeben und eingeleitet von B. Laufer. *Abhandlungen Königl. Bayer. Akad. d. Wissenschaften,* Vol. XXVII, No. 1, 442 pp. 1915. Preface and Introduction (pp. v-xxiv) written by B. Laufer.

The Si-Hia language, a study in Indo-Chinese philology. *T'oung Pao,* 1916, pp. 1-126.

Supplementary notes on walrus and narwhal ivory. *T'oung Pao,* 1916, pp. 348-389.

Se-Tiao. *T'oung Pao,* 1916, p. 390.

The beginnings of porcelain in China. With a technical report by H. W. Nichols. 12 plates and 2 text-figures. *Field Museum Anthropologicat Series,* Vol. XV, No. 2, pp. 77-182, 1916. The date was arbitrarily changed by the printer to 1917. 106 pp. 7 plates.

Cardan's suspension in China. 1 plate, 1 text-figure. *Holmes Anniversary Volume,* 1916, pp. 288-291.

Review of R. Garbe, *Indien und das Christentum. American Anthropologist,* Vol. XVIII, 1916, pp. 567-573.

Review of J. E. Pogue, *The Turquois. American Anthropologist,* Vol. XVIII, 1916, pp. 585-590.

Burkhan. *Journal American Oriental Society,* vol. XXXVI, 1917, pp. 390-395. Additional note, vol. XXXVII, 1917, pp. 167, 168.

Concerning the history of finger-prints. *Science,* 1917, May 25, pp. 504, 505.

Moccasins. *American Anthropologist,* 1917, pp. 297-301.

Origin of the word Shaman. *American Anthropologist,* 1917, pp. 361-371.

The reindeer and its domestication. *Memoirs, Anthropological Association,* Vol. IV, No. 2, 1917, pp. 91-147.

The vigesimal and decimal systems in the Ainu numerals. *With some remarks on Ainu Phonology. Journal American Oriental Society,* Vol. XXXVII, 1917, pp. 192-208.

The language of the Yüe-Chi or Indo-Scythians. Chicago, R. R. Donnelley and Sons Co., 1917, 14 pp. Privately printed in 50 copies.

Collection of ivory seals in the possession of Mrs. George T. Smith. Privately printed, 1917.

Loan-words in Tibetan. *T'oung Pao,* 1916, pp. 403-552. Leyden, E. J. Brill, 1918.

Religious and artistic thought in Ancient China. *Art and Archaeology,* Dec., 1917, pp. 295-310. 16 illustrations.

Reviews of Diels, *Antike Technik;* Mookerji, *Indian Shipping;* Parmentier, *Guide au Musée de l'Ecole française;* Maspero, *Grammaire de la langue khmere. American Anthropologist,* 1917, pp. 71-80, 280-285.

Totemic traces among the Indo-Chinese. *Journal American Folk-lore,* Vol. XXX, 1917, pp. 415-426.

Origin of Tibetan writing. *Journal American Oriental Society,* Vol. XXXVIII, 1918, pp. 34-46.

Edouard Chavannes (Obituary Notice). *Journal American Oriental Society,* Vol. XXXVIII, 1918, pp. 202-205.

Reviews of Lowie, *Culture and ethnology, American Anthropologist,* Vol. XX, 1918, pp. 87-91; Foote, *Foote Coll. of Indian antiquities,* and Rea, *Cat. Prehistoric ant. from Adichanallur,* ibid., pp. 104-106.

La Mandragore (in French). *T'oung Pao,* 1917, pp. 1-30; published 1918.

Malabathron (in French). *Journal asiatique,* Paris, 1918, 50 pp., 12 figures.

The Chinese exhibition. *Bulletin, Art Institute of Chicago,* Dec., 1918, pp. 144-147.

Sino-Iranica. Chinese contributions to the history of civilization in Ancient Iran, with special reference to the history of cultivated plants and products. *Field Museum Anthropological Series,* Vol. XV, 1919, No. 3, 446 pp.

Reviews of Tallgren, *Collection tovestine des antiquités préhist. de Minoussinsk;* Sarkar, *Hindu achievements in exact science;* Starr, *Korean Buddhism;* Mauger, *Quelques considérations sur les jeux en Chine;* Couling, *Encyclopaedia Sinica. American Anthropologist,* Vol. XXI, 1919, pp. 78-89. Also, M. Czaplička, *Turks of Central Asia;* G. Ferrand, *Malaka, le Malaya et Malayur,* and *Apropos d'une carte javannaise du XVI[e] siècle;* R. Torii, *Études archeologiques. Les Ainu des Iles Kouriles, op. cit.,* pp. 198, 301-308, 459.

Coca and betel-chewing: A query. *American Anthropologist,* Vol. XXI, 1919, pp. 335, 336.

Sanskrit Karketana (in French). *Mémoires de la Société de Linguistique,* Vol. XXII, 1922, pp. 43-46.

Multiple births among the Chinese. *American Journal Physical Anthropology,* Vol. III, 1920, No. 1, pp. 83-96; and *New China Review,* Shanghai, Vol. II, April, 1920, pp. 109-136.

Sex transformation and hermaphrodites in China. *American Journal Physical Anthropology,* Vol. III, 1920, No. 2, pp. 259-262.

The reindeer once more. *American Anthropologist,* Vol. XXII, 1920, pp. 192-197.

Twelve articles and frontispiece contributed to H. Cordier, *Ser Marco Polo,* Murray, London, 1920.

Review of L. Wiener, *Africa and the Discovery of America. Literary Review* of the *New York Evening Post,* Feb. 5, 1921.

Review of H. Cordier, *Ser Marco Polo: Notes and addenda to Sir Henry Yule's Edition, 1920. American Historical Review,* Vol. XXVI, No. 3, April, 1921, pp. 499-501.

Milaraspa. *Tibetische Texte in auswahl übertragen.* Folkwang-Verlag, Hagen, 1922.

A bird's-eye view of Chinese art. *Journal American Institute of Architects,* Vol. X, No. 6, 1922, pp. 183-198. 23 text-figures.

The Chinese gateway. *Field Museum Anthropological leaflet* No. 1, 1922, pp. 1-7. 1 plate.

Archaic Chinese bronzes of the Shang, Chou and Han periods. New York, Parish-Watson, 1922, 24 pp., 4°. 10 plates.

Use of human skulls and bones in Tibet. *Field Museum Anthropological Leaflet* No. 10, Chicago, 1923, 16 pp. 1 plate.

Oriental theatricals. *Field Museum, Guide,* Part I, Chicago, 1923. 60 pp. 11 plates in photogravure.

Review of Shirokogoroff, *Social organization of the Manchus. American Anthropologist,* Vol. XXVI, 1924, pp. 540-543.

Tobacco and its use in Asia. *Field Museum Anthropological Leaflet* No. 18, 1924, 40 pp. 10 plates in photogravure.

The introduction of tobacco into Europe. *Field Museum Anthropological Leaflet* No. 19, 1924, 66 pp.

Tang, Sung and Yüan paintings, Paris and Brussels. G. van Oest and Company, 1924, 22 pp., folio. 30 plates.

Chinese baskets. *Anthropology Design Series* No. 3, Field Museum, Chicago, 1925. 38 plates in photogravure, 2 pp. text, quarto.

The tree-climbing fish. *China Journal of Science and Arts,* Vol. III, 1925, No. 1, pp. 34-36.

Archaic bronzes of China. *Art in America,* Vol. XIII, No. 6, pp. 291-307. 4 plates.

Jurchi and Mongol numerals. *Korosi Csoma-Archiv,* Vol. I, No. 2, Dec., 1921, pp. 112-115.

Ivory in China. *Field Museum Anthropological Leaflet* No. 21. 1925, 78 pp. 10 plates in photogravure.

Review of H. A. Giles, *Strange stories from a Chinese studio. Journal of American Folk-lore,* Vol. XXXIX, 1926, pp. 86-90.

The Jan Kleykamp collection, Chinese and Japanese paintings. New York, 1925, 40 pp., folio. 40 plates.

Ostrich egg-shell cups of Mesopotamia and the ostrich in ancient and modern times. *Field Museum Anthropological Leaflet* No. 23, 1926, 52 pp. 9 plates in photogravure, 10 text-figures, 1 cover design.

History of ink in China, Japan, Central Asia, India, Egypt, Palestine, Greece, and Italy. In F. B. Wiborg, *Printing Ink, a History.* Harper Bros., New York, 1926, pp. 1-76.

Archaic Chinese jades collected in China by A. W. Bahr. Now in Field Museum of Natural History of Chicago. 52 pp., 36 plates, 3 of which are colored. New York. Printed privately for A. W. Bahr by R. R. Donnelley and Sons Co., Chicago, 1927.

Methods in the study of domestications. *Scientific Monthly,* Sept., 1927, pp. 251-255.

Review of T. F. Carter, *Invention of printing in China. Journal American Oriental Society,* Vol. XLVII, 1927, pp. 71-76.

Agate, archaeology and folk-lore. *Field Museum Geology Leaflet* No. 8, 1927, pp. 20-35. Illustrated.

Insect-musicians and cricket champions of China. *Field Museum Anthropological Leaflet* No. 22, 1927, 28 pp. 12 plates in photogravure.

The giraffe in history and art. *Field Museum Anthropological Leaflet* No. 27, 100 pp. 9 plates in photogravure, 23 text-figures, 1 vignette, 1 colored cover design. Notice in *Quarterly Review of Biology* IV, 1929, p. 138.

Cricket champions of China. *Scientific American,* Jan., 1928, pp. 30-34. Illustrated.

The prehistory of aviation. *Field Museum Anthropological Series,* Vol. XVIII, No. 1, 1928, 100 pp. 12 plates in photogravure and 1 vignette.

The prehistory of television. *Scientific Monthly,* Nov., 1928, pp. 455-459.

Review of H. Maspero, *La Chine antique. American Historical Review,* Vol. XXXIII, 1928, pp. 903, 904.

Turtle fossil arouses interest of scientists (Laufer quoted as authority). *Scientific American,* May, 1929, pp. 451- 452.

Review of W. Barthold, *Turkestan down to the Mongol Invasion. American Historical Review,* Vol. XXXIV, 1929, pp. 378, 379.

Review of Chi Li, *The Formation of the Chinese People: An Anthropological Inquiry. American Historical Review,* Vol. XXXIV, 1929, pp. 650, 651.

The American plant migration. Reprinted from *Scientific Monthly,* March, 1929, Vol. XXVIII, pp. 239-251.

On the possible origin of our word booze. *Journal of American Oriental Society,* Vol. XLIX, 1929, pp. 56-58.

The early history of felt. Reprinted from *American Anthropologist,* Vol. XXXII, No. 1, January-March, 1930, pp. 1-18.

A Chinese-Hebrew manuscript. A new source for the history of the Chinese Jews. Reprinted from *American Journal of Semitic Languages and Literatures,* Vol. XLVI, No. 3, April, 1930, pp. 189-197.

Mission of Chinese students. *Chinese Social and Political Science Review,* Vol. XIII, No. 3, July, 1929, pp. 285-289.

The Gest Chinese research library at McGill University. Montreal, 1929.

The Eumorfopoulos Chinese bronzes. *Burlington Magazine*, Vol. LIV, 1929, pp. 330-336.
Catalogue of a collection of Chinese paintings in the possession of Dr. Frederick Peterson. 1930.
Felt. How it was made and used in ancient times and a brief description of modern methods of manufacture and uses. Chicago, Western Felt Works, 1930. John Crerar Library.
Chinese bells, drums and mirrors. *Burlington Magazine*, Vol. LVII, pp. 183-187. London, October, 1930.
Geophagy. *Field Museum Anthropological Series*, Vol. XVIII, No. 2, Chicago, 1930, pp. 101-198.
Tobacco and its use in Africa. *Field Museum Anthropological Leaflet* No. 29, 1930. By B. Laufer, W. D. Hambly, and R. Linton.
The restoration of ancient bronzes and cure of malignant patina. By Henry W. Nichols, with foreword by Berthold Laufer. Aug., 1930. *Museum Technique Series*, No. 3.
Columbus and Cathay, and the meaning of America to the Orientalist. *Journal American Oriental Society*, Vol. LI, 1931, pp. 87-103.
China and the discovery of America. A monograph published by the China Institute in America. New York, 1931.
The domestication of the cormorant in China and Japan. *Field Museum Anthropological Series*, Vol. XVIII, No. 3, 1931, pp. 205-262.
Inspirational dreams in Eastern Asia. *American Folk-lore Journal*, Vol. XLIV, 1931, pp. 208-216.
The prehistory of aviation. *Open Court*, Vol. XLV, 1931, pp. 493-512. Illustrated.
Tobacco in New Guinea. *American Anthropologist*, Vol. XXXIII, 1931, pp. 138-140.
Paper and printing in Ancient China. Printed for the Caxton Club. Chicago, 1931.
A defender of the faith and his miracles. *Open Court*, Vol. XLVI, 1932, pp. 665-667.
The early history of polo. *Polo, The Magazine for Horsemen*, Vol. VII, 5, Apr. 1932, pp. 13, 14, 43, 44.
Sino-American points of contact. *Scientific Monthly*, Vol. XXXIV, 1932. *Open Court*, Vol. XLVII, 1933, pp. 495-499.
East and West. *Open Court*, Vol. XLVII, 1933, pp. 473-478.
The Jehol pagoda model. *Field Museum News*, Vol. IV, 1933.
Turtle Island. *Open Court*, Vol. XLVII, 1933, pp. 500-504.
Prefaces to *Monograph Series of the New Orient Society of America*. Second Series, 1933. 1. China No. 5; 2. Central and Russian Asia No. 2.
Foreword to Henry Field, *Prehistoric Man. Field Museum Anthropology Leaflet* No. 31, pp. 3, 4. Chicago, 1933.

A defender of the faith. *Asia,* Vol. XXXIV, May, 1934, pp. 290, 291.

Etruscans. *Field Museum News,* Vol. V, 1934.

The lemon in China and elsewhere. *Journal American Oriental Society,* vol. LIV, 1934, pp. 143-160.

Rare Chinese brush-holder. *Field Museum News,* Vol. V, 1934.

The Chinese imperial gold collection. A Century of Progress, 1934. Parish-Watson & Co., Inc., New York, 1934.

The Swing in China. *Memoires de la Société Finno-Ougrienne,* Vol. LVII, 1934.

The Noria or Persian wheel. *Pavry Memorial Volume,* London, 1933. Oxford University Press, pp. 238-250.

Chinese Muhammedan bronzes. *Ars Islamica,* Vol. I, 1934, pp. 133-147. Illustrated.

Rye in the Far East and the Asiatic origin of our word series "Rye." *T'oung Pao,* Vol. XXXI, 1935, pp. 237-273.

Not included in the above bibliography are the Reports of the Department of Anthropology, Field Museum, published in the Director's Annual Reports, 1915-1933. These, however, do not appear over Laufer's signature.

Dr. Laufer was the editor of all anthropological publications, leaflets, guides, and design series issued by the Field Museum from 1915 to his death.

In addition, Dr. Laufer left the following unfinished manuscripts:

The Buceros and Hornbill carvings.

History of the cultivated plants of America and their distribution over the Old World. 2 vols., ca. 800-900 pp.

Jade, second revised and enlarged edition.

Chinese domestications, pt. 1: Chicken, Cormorant, and Cat. Five Prehistories.

A History of the Game of Polo.

John J. Carty

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OF

JOHN JOSEPH CARTY

1861–1932

BY

FRANK B. JEWETT

PRESENTED TO THE ACADEMY AT THE AUTUMN MEETING, 1936

JOHN JOSEPH CARTY

1861–1932

By Frank B. Jewett

Henry Carty, the father of John J(oseph), emigrated to America in 1825, when eighteen years of age. He landed at Eastport, Maine, and after trying work on a nearby farm, moved on, finally reaching Cambridge, Massachusetts, where he settled and learned the machinist's trade. Here he married Elizabeth O'Malley who, like himself, was of Irish lineage. It is reported that fortune smiled rather genially upon the couple and that they became respected and comfortably well-to-do citizens of their adopted city.

John J., the fourth child of the union of Henry and Elizabeth, was born in Cambridge, April 14, 1861. During Carty's boyhood, his father operated a bell foundry. It does not appear that he evinced more interest in his father's profession than might have been shown by any normal youngster, but he did give evidence of being strongly attracted by physics, and in particular by electrical science which was then quite in its infancy. His first schooling was in the Allston Grammar School, where he had the good fortune to come under the tutelage of a G. W. Roberts, the master of the school. Viewing his youthful days in retrospect, Carty once said affectionately, almost reverently: "People like 'Donkey' Roberts don't exist nowadays; ours is the era of the chain-store fellows."

From the Allston Grammar School, Carty passed to the Cambridge Latin School, with the intention after graduation of carrying out his parents' wishes by entering Harvard College and then finishing with a course in the Law School. But the plans for making a lawyer of John J. Carty never reached fruition, although in view of the qualities of intellect he later disclosed there can be little doubt that he would have made a most brilliant and able barrister. At a critical moment, trouble developed in his eyes and became so acute that for a time he was compelled to discontinue all study. Rather than graduate behind

his old classmates, Carty, then seventeen years of age, decided to seek employment. Following his natural bent, the first job was in a shop devoted to the sale of, as the phrase then went, "philosophical apparatus," and of which the proprietor was one Thomas Hall. Although the atmosphere of the shop quite satisfied his youthful curiosity, his employment there was short-lived and terminated abruptly when he electroplated some old bits of brass to make them appear like gold and left them for Mr. Hall to discover.

From the scientific shop, Carty seems to have wandered quite by chance to the office of the Boston Telephone Despatch Company, where E. T. Holmes was operating a small telephone exchange as an adjunct to an already established burglar alarm system. This exchange included a switchboard for interconnecting telephone lines. After an interview with the superintendent, Carty was hired at twice his former wage to serve as one of the boy operators. Thus began his lifelong connection with the telephone business. Years afterward, speaking of the boy operators, he said that they made very poor precursors to the girls; "They were not old enough to be talked to like men, and they were not young enough to be spanked like children."

Carty's service with the Boston Telephone Despatch Company and with the New England Telephone and Telegraph Company continued from 1879 to 1887. He soon passed from the ranks of the boy operators to work involving design, construction and maintenance, and he early showed facility at finding ways to improve the primitive, almost naive, apparatus and methods which characterized the earliest years of the telephone art. One of his outstanding contributions, made in 1881, was the application to commercial use of the full metallic circuit instead of the single grounded wire which had been previously used and which had been borrowed from the telegraph art as it then existed. It was also at this time that Carty laid the foundation of what was later to become the common battery telephone system. This momentous development required several years to perfect, however, and his most valuable inventions pertaining to it did not arise for another decade.

A complete list of Carty's patents comprises twenty-four in all, which were issued in the period between 1883 and 1896. There were other inventors whose contributions to the telephone art were more numerous than Carty's, but no contemporary excelled him in the importance of his inventions; for example, his common battery switchboard, his bridging bell and his transformer or repeating coil type of phantom circuit are as fundamental to the telephone art of today as they were forty years ago.

In 1887, Carty left Boston and the New England Telephone and Telegraph Company to take charge of the telephone cable department of the Western Electric Company with headquarters in New York. His genius appears to have been too many-sided, however, for him to remain long in this rather specialized work. From the cable department he passed to the switchboard department and then, in November of 1889, was appointed "Electrician" of the Metropolitan Telephone and Telegraph Company, now the New York Telephone Company. Thus, in his twenty-eighth year, he stood as the technical chief of what was then the greatest telephone system in any city in the world.

Had Carty's contributions to the communications art extended no further than the inventions and developments just noted, he would have lived and been remembered today as one of the greatest of telephone engineers, but his genius was as remarkable for its power to visualize the needs and possibilities of the future as to solve particular problems once they had arisen in concrete form. He not only foresaw that the business was destined to be an extremely technical one but had the courage to act upon this vision and build up a scientific department years in advance of the time when it became the practice of the industry to employ trained scientists and investigators. More than this, he conceived one of the functions of his engineering department to be that of a training school for the men who would later become officials of the company. Carty was, therefore, one of the early initiators of industrial research and one of its most ardent advocates. During his long career as Chief Engineer of the American Telephone and Telegraph Company and later as

Vice President, he brought into being what is thus far the world's largest industrial research organization, an organization which through his wise leadership rapidly placed the United States as the foremost nation in matters telephonic.

In reviewing the outstanding activities of Carty's life, one is tempted to say that they all sprang from a single guiding principle or motif, namely, a passionate belief in the value of the communion of mind with mind and the smooth collectivity of action which would in time arise therefrom. Such a motif accounts, of course, for the fact that he dedicated himself without reserve to the telephone and its future. It accounts equally for the type of research organization which he built up to insure the materialization of the future of which he dreamed. Even from the days of his earliest association with it, he seems to have entertained a firm conviction that the telephone was destined to make possible a nation-wide transmission of speech. To his maturer mind, such a far-flung network of telephone lines became more than an arrangement for exchanging conversations. He thought of it as a national nervous system, binding the people and the geographical units of the country together and serving indispensably that collectivity of action which is the ultimate goal of superorganic evolution.

In the importance which Carty attached to human cooperation, he was a true disciple of Herbert Spencer. He knew that in human society, the whole is much greater than the sum of its parts; that individuals by themselves could never reach the same high level of output, either intellectually or materially, that could characterize the group under harmonious cooperation. It was from this standpoint that he appraised the research organization he had brought into existence. To him it was more than a group of individuals,—it was a sort of collective mind which, made up of experts in many fields who collaborated continually with one another, could arrive quickly at the solutions of problems so intricate in their ramifications as to require years of single-handed effort, if indeed they could be solved at all single-handed. Such research organizations Carty constantly advocated in his public addresses as one of the most important contributions of

our age to the progress of mankind. He in turn seemed to obtain a double satisfaction from the fact that the laboratory—the collective research mind—whose work he directed was developing a nervous system for the nation as a whole, so that it in turn might function more smoothly as a well-integrated organism and reach that higher goal which represents perfectly coordinated cooperative effort.

This is the theme which Carty promised himself he would elaborate after retirement from active service. Unfortunately, an untimely death prevented. As matters stand, it finds scant place in any of his writings for these were usually directed to an immediate end, and the pressure of his life was such that he economized words on every occasion. A few brief paragraphs taken from his address, "Science and the Social Organism," delivered in celebration of the twenty-fifth anniversary of the Cold Spring Harbor Laboratory of the Carnegie Institution, are, however, worth noting here.

"The awful spectacle of the increasing numbers of the mentally sick, the prevalence of nervous diseases, and the generally disturbed condition of the nations, have caused many to believe that we are headed in the wrong direction, and that our ideals should be those of the so-called simple life, or that we should seek to attain to the static condition of ancient China. Were it not for my faith in the ultimate success of such researches as you are conducting in this institution, I believe that I, too, would share these views and be inclined to the opinion that in merely material progress we had gone far enough—perhaps too far, or too fast.

"While I have frequently asserted that human behavior presents the most important and the most formidable problem of all the ages, I believe that its solution can be achieved. . . .

"To me, this celebration today is an event of the deepest significance, for it indicates the beginning of a new era of social development. As Trotter* so well puts it:

" 'The method of leaving the development of society to the confused welter of forces which prevail within it is now at last reduced to absurdity by the unmistakable teaching of events. The conscious direction of man's destiny is plainly indicated by

* W. Trotter.—Instincts of the Herd in Peace and War:

Nature as the only mechanism by which the social life of so complex an animal can be guaranteed against disaster and brought to yield its full possibilities.

" 'A gregarious unit informed by conscious direction represents a biological mechanism of a wholly new type, a stage of advance in the evolutionary process capable of consolidating the supremacy of man and carrying to its full extent the development of his social instincts.'

"Human progress need no longer be left solely to chance. By the aid of science, it can be brought under our conscious control.

"In concluding, let me say that if we rightly interpret the work of these scientists which we are briefly to examine today, we shall find that it is directed ultimately to the overcoming of the defects both of body and mind which are found in the individual man, and which now prevent him from properly performing his function as a member of society. We shall also, I think, be made to feel that in the great plan of creation, the highest part has been assigned to man; for he must direct the development of that social organism which has been foreshadowed 'with its million-minded knowledge and power, to which no barrier will be insurmountable, no gulf impassable and no task too great.' "

For some years after Carty assumed administrative work, he still found time to indulge his strong natural bent for original investigation. It was in this period that he carried on his fundamental researches regarding the nature of the electrical induction between parallel circuits which, in telephone parlance, gives rise to "crosstalk," i.e., to the transfer of part of the speech energy from one circuit to another parallel to it. It had been commonly supposed that the induction was largely electromagnetic. Carty was able to prove that it was, on the contrary, largely electrostatic. In 1889 he published an account of this work, pointing out that "there is in the telephone line a particular point at which, if a telephone instrument be inserted, no crosstalk will be overheard." He gives directions for determining the location of this neutral point, and goes on to develop the ideas of electrical balance and the transposing of circuits—two operations which are of fundamental importance in the art today. From this period there also came his contribution of the bridging bell, a circuit which he was forced to evolve to meet an embarrassing contract into which his company had entered with the New York

Central Railroad to supply them with a multiparty private line, but which rapidly found widespread use in a multitude of rural lines all over the country.

It is an interesting side-light on Carty's fecundity of mind that during this strenuous period when he was guiding the engineering and research activities of an adolescent telephone industry and organizing and building up the nucleus of what was later to become the Bell Telephone Laboratories, and was indeed personally leading the attack on many problems, he found time to write regularly for the *Electrical Review*. These contributions were known as "The Prophet's Column" and appear to have supplied him a sort of mental relaxation—he seldom, if ever, resorted to physical exercise as a means of relaxation. His discussions were usually in the lighter vein and offered the opportunity of mixing mild doses of scientific information with a leavening of humor, for, true to his Irish ancestry, he had an inexhaustible store of the latter continually bubbling up for release. A single quotation will serve by way of illustration.

"The man who could have bought Bell Telephone stock at $10 a share and didn't is now becoming extinct. His favorite haunt was the smoking compartment of a Pullman car, where he was wont to repeat the oft-told tale of the grocer who did and got it in payment of a bad debt at that. In his place we have another specimen quite as easy to recognize. After some of the strange tales of electrical science have been discussed, he is sure to gravely remark, as though it had never been uttered before, 'Well, electricity is in its infancy,' and quickly add the inevitable corollary, 'but it's the coming power, though.'

"Just watch this man. You will be surprised to see how many there are of him. He is the Public. You must study his moods and lead him aright. The marvelous products of electrical science have so charmed his mind that no story of its newly discovered powers can be so much at variance with the laws of nature as not to be received by him with ready belief."

In 1893, Carty was elected an Honorary Fellow of the American Electrotherapeutic Association, in recognition of his success in the self-imposed task of rationalizing the electrical terminology of the medical profession of that day. He inveighed strongly against such puzzling and nonsensical terms as Farad-

ism, Franklinism and Galvanism and a host of others, submitting to medical men an earnest plea for the revision of their electrical nomenclature in accordance with the language of physics. Thus we see again clear evidence of Carty's insistence on clarity of thought.

As the prime requirement of a leader is accuracy of thought and clearness of vision, it is worth quoting at some length from Carty's paper of 1906 entitled "Telephone Engineering" delivered before the American Institute of Electrical Engineers. It is a lucid exposition of the responsibilities of the telephone engineer or, with proper changes in terminology, of the engineer in general. In closing this paper, he said:

"From beginning to end, the engineer is thus placed in a position to exercise a veto power upon any adverse methods which might otherwise be allowed to creep in. . . .

"The importance of this coordinating function cannot be overestimated and it is only at some central point that such function can be exercised. Being judged from the maintenance point of view, a piece of apparatus might have qualities of a high order; but when considered with reference to its effect upon the traffic, difficulties might be discovered which would entirely overweigh the maintenance advantages. In such a case the conflicting claims with respect to the apparatus must be judiciously considered by the engineer, and his decision must be rendered with a view to producing the best net result.

"Again, systems might be proposed which, considered solely from the maintenance, construction and traffic points of view, might seem to possess all of the advantages of an ideal arrangement; but when considered from the standpoint of the efficiency of transmission might be found to involve an impairment of transmission on one hand or such increase in cable and line costs on the other hand as to render its use out of the question.

"In order to exercise proper coordinating functions, it is essential that the engineer should be placed and should maintain himself in such relations with all of the departments of the telephone organization that he may get from them and fairly consider all of the projects and ideas pertaining to the design, operation, construction and maintenance of the plant which naturally originate in such departments when they are conducted with proper efficiency.

"Viewed from this standpoint, it will be seen that while the

function of the engineer with relation to the plant is of the utmost importance, nevertheless the work of the traffic, maintenance, construction and other departments has such an important bearing upon the whole question, that the successful engineering of a telephone system must be regarded not only as the work of the engineer himself but as the work of all of the other departments concerned. Not only this, but what is still more important, the successful engineering of a telephone plant depends upon proper business management, as I have indicated by several striking examples. Without an intelligent, progressive and broad-gauged business management, there cannot be good telephone engineering."

In 1908, Carty, who had become Chief Engineer of the American Telephone and Telegraph Company in 1907, visited the Pacific coast to assist the local telephone officials in formulating plans for rebuilding and enlarging the telephone plant. He was accompanied by some of his assistants and was joined later by T. N. Vail, then President of the American Telephone and Telegraph Company. San Francisco was in the initial stages of cleaning up the debris of earthquake and fire preparatory to building a new city and of christening it with a great international exposition.

The hardihood and daring of the program appealed to both Vail and Carty, as did the urgent demand of the citizens, that the Pacific and Atlantic coasts be linked telephonically by the time the job was done. To Carty, accustomed as he was to daily talks with associates even though hundreds of miles away, the sense of remoteness caused by this western trip was oppressive. As he observed with a twinkle in his eye to a native son of California, he "was greatly impressed with the isolation of the rest of the country."

However, to promise meant to fulfill and how could more than three thousand miles of distance be spanned telephonically when the existing art had conquered even poorly but half that distance? Night after night, for weeks on end, after hard days on current problems, Carty and two or three of his associates spent evenings in their hotel among the ruins analysing the possibilities of an unconquered future. Finally the chances of suc-

cess were established to Carty's satisfaction and the promise was given—to be sealed irrevocably next morning by glaring newspaper headlines.

Carty returned to New York to put the necessary machinery in motion for this gamble with Fate. Six years later saw the opening of the first transcontinental wire line, and a few months afterward, using very nearly the same instrumentalities, he was able to announce the first successful transmission of the voice by radio telephone across the Atlantic and also across the American continent and as far out into the Pacific as Honolulu. During these six years, Carty was at the apex of his powers. He drove himself and his associates with a force that was untiring and unsparing. Sleep and relaxation in small doses were grudgingly accorded. For the rest it was unceasing labor with the success of the organization, which was his life, and the good of the nation he loved, as the goal.

Both the opening of the transcontinental telephone line and the first transmission of speech by radio to Paris occurred in 1915 after the outbreak of the World War. The military importance of the enormous extension of the scope of telephony which these two events signalized led General McComb, President of the Army War College, to invite Carty to deliver a confidential lecture before that body on "The Organization, Plant and Personnel of the Bell System." This lecture was repeated a few weeks later before the Naval War College. From these two appearances there followed a series of events leading up to the subsequent extensive utilization of the facilities of the Bell System by the Army and Navy. There was springing up in high places a very definite realization of the military importance of the latest telephone developments, and a belief that the research facilities of the Bell Telephone organization could probably contribute still other new devices of value in the national defense, in case the United States were forced into the hostilities. The Honorable Josephus Daniels, Secretary of the Navy, wrote to T. N. Vail, President of the American Telephone and Telegraph Company, "appealing to the patriotic sense of this Company" and inquiring whether it was in a position to give the Navy De-

partment "a demonstration of what could be accomplished in the way of communication, particularly in long distance telephony and telegraphy, which would bring the offices of the Department and the Navy Yards and Stations within the limits of the United States proper into that close touch which the exigencies of war might demand."

"In order that this mobilization of forces of communication may be complete, and recalling the close cooperation of officials of the Department in the past with the officials of your Company in the development of the wireless telephone, it is confidently hoped that its use as a means of communication with a ship at sea could also be demonstrated at the same time under such conditions as might be mutually agreed upon." The Secretary added, "Congress provides no funds whereby the expense of such a demonstration could be borne by the Government and thereby recognizes that whatever is done by your Company will have to be free of all expense to the Department."

The cooperation of Carty and his research staff to this request and similar ones from the Signal Corps of the Army was immediately forthcoming, and among other contributions there should be mentioned particularly a sturdy radio telephone outfit that was extensively used on aircraft and on destroyers and submarine chasers. The American Army, of all those in the field, alone was able to avail itself of the aid of radio telephony.

But Carty, ever mindful of the personnel side of every situation, realized that physical things alone would not suffice. To be effective they must be in the hands of a properly qualified operating organization. Thus, while on the one hand, he brought to the administration at Washington a realization of what the telephone art and the telephone organization could offer, he also arranged a complete plan of action with the executives of the Bell organization. Addressing a conference of Presidents of the companies comprising the Bell System, he said:

"Our plans contemplate two classes of Signal Corps officers to be recruited from the Bell System. One of these is to consist of engineers and executives who will remain in their offices,—representing the War Department and taking their orders direct

from Washington. Their duty will be to direct the highest possible military utilization of the Bell System plant and personnel, without at the same time crippling the service as a whole.

"The other group will consist also of executives and engineers, who will select and organize the trained personnel of the Bell System into companies and battalions, for such field service as occasion may require. I cannot, of course, take final steps in this vital programme without your support. I now ask that support. We must act as a unit."

Again Carty's foresight and his forceful call to action were vindicated. When war was declared with Germany, the entire Signal Corps personnel, including men in the field as well as a small group at headquarters, consisted of 55 officers and 1570 men. Within a few months, this nuclear organization was swelled by 4525 persons taken out of the Bell System alone.

Then the question arose as to how to equip the Army shortly to depart for France. The military type of telephone and telegraph apparatus theretofore employed was simple in design, sturdy in construction, and not easily put out of order, but its capabilities were extremely limited in comparison with the latest results which the commercial system in the United States was obtaining. The new apparatus was complicated and delicate, and the unfavorable conditions of warfare would tax it in a manner never experienced before. Should Carty, to whom the Army had turned for guidance, recommend that our Army be provided with such a modern communication system capable of furnishing a service virtually unlimited both as to message carrying capacity and as to distance, or should he recommend the traditional Army equipment? It was a vital decision. He had confidence that the men he would send to France could make a success of the system employing the newly developed telephonic repeaters and utilizing the latest type of multiplex printing telegraph apparatus. Weighing the factors involved, he concluded that the advantages of modern equipment were too great to be disregarded, and with what success the following quotations will indicate. Speaking after the war was over, before the Committee on Military Affairs of the House of Representatives, he said:

"There had been preparations made for war in the European terrain for forty years. When the war broke it was not possible for any of the European nations to provide a communication system adequate for the conduct of the war. It remained for the Signal Corps of the U. S. Army in nine months to construct a long distance telegraph and telephone system which the Governments of Europe had failed to do in forty years."

For the first time, it became possible to talk from Paris to Rome, and from Marseilles in the south to Le Havre, and even across the Channel to London and Liverpool. And, following the Armistice, Colonel (later General) Saltzman, Acting Chief Signal Officer of the Army, wrote Carty, saying:

"In the operations in France, our Army has enjoyed a wonderful system of communication of an efficiency and capacity never before contemplated in the history of warfare. In considering the initial conception and the successful operation of this system, the Signal Corps will ever remember your splendid foresight and the technical efficiency of the thousands of trained men that you brought into the service. It would be very difficult to place a value on the services which you have rendered to our country in this connection alone."

In recognition of his service during the war, Carty was on October 23, 1921, created a Brigadier General in the Officers' Reserve Corps.

Following the cessation of hostilities, Carty again returned to the commercial and social aspects of the telephone. Always in the background of his thoughts was the idea of adapting the telephone more and more fully and intimately to the needs of the country, so that to the greatest extent possible it could play its part in facilitating harmony of action. A memorable instance of this occurred at the burial of the Unknown Soldier in Arlington Cemetery, November 11, 1921. Realizing the dramatic possibilities inherent in the ceremony, he offered to the administration in Washington the nation-wide use of the public address system which had but recently emanated from the telephone laboratories. His offer was accepted and circuits, amplifiers and loud speakers were so arranged that thousands of people in New York and San Francisco as well as in Washington heard and

participated in the entire service—the invocation of the chaplain, the words of the commitment—and finally, at the close, joined with the President in reciting the Lord's Prayer.

So rapidly have events moved in the field of electrical communication that it is difficult now to realize that at that time, scarcely fifteen years ago, radio broadcasting was an unknown development. At the burial ceremony, the entire transmission was by wire telephone lines, and the multitudes who heard were of necessity gathered within earshot of powerful loud speakers—in Madison Square and Madison Square Garden in New York and in the great Civic Plaza in San Francisco. In a very real sense, as we look back upon this outstanding occasion, it may be said that Carty was the father of broadcasting. Today, the local distribution of programs takes place by radio while, as in that occurrence, the broadcasting stations themselves are tied together by long distance telephone circuits. Radio stations together with receiving sets in the hands of the public have displaced Carty's powerful loud speakers but not the nation-wide network of long distance wire lines. On a somewhat similar occasion in February, 1924, after radio broadcasting had appeared, Carty connected seven large broadcasting stations by a telephone circuit extending from San Francisco to Havana, a distance of more than five thousand miles. This constituted a forerunner of chain broadcasting as we know it today, and newspapers at the time estimated that no less than fifty million radio listeners heard the program, which comprised portions originating at several points along the route. Carty himself remarked:

"We are only just beginning to appreciate how fundamental are electrical communications in the organization of society. We are as yet unable to appreciate how vital they are to the ultimate welfare of mankind. I believe that some day we will build up a great world telephone system,—which will join all the people of the earth into one brotherhood."

This was the goal for which he worked unremittingly and the later years of his life enabled him in large measure to provide the material accessories necessary to the realization of his vision.

Just fifty years after the invention of the telephone, the first two-way conversation was heard across the Atlantic Ocean, and the year following regular commercial service with England was begun. Beginning with this single overseas circuit, progress became so rapid that now it is possible for any telephone anywhere in the United States to be connected with about ninety-eight per cent of all the telephones in the world.

For some years, of course, Carty had made no technical contributions to this epic of progress, but his was the vision and the generalship which on the one hand created an engineering and scientific organization capable of solving the countless problems involved, and on the other convinced those who held the purse-strings that the financial risk they were taking was one which some day they would be very grateful for having taken.

In the case of one who was as firm a believer in the value of scientific research, both fundamental and applied, and who was so successful in inspiring it as Carty, it is not surprising that his counsel was frequently sought by others and that he undertook a considerable amount of proselytizing. Most of the addresses which he gave during the later years of his life were devoted to pointing out the benefits which the world had reaped by the industrial application of science and to evaluating these benefits both in terms of human comfort and conveniences and in terms of money. These addresses contain characteristic phrases and similes. Carty always took delight in coining a new one, but the old ones were seldom discarded. Thus, "Science and the Industries," which was given before the National Research Council, February 6, 1920, contains an allusion to the North American Indian. Referring to the rapid strides which science had been making in recent decades, he pictured "future generations looking back upon us with our present limited knowledge of the forces of Nature as we now regard the North American Indian who, cold and shivering in his scanty clothing, was ignorant of the coal at his feet with its stores of warmth and power." To this Indian, Carty frequently and jocularly referred as his "star performer."

In many other ways, Carty fostered the interests of science, both at home and throughout the world. In 1923, he was elected to the Board of Trustees of the Carnegie Corporation. He was a Trustee of the Carnegie Institution of Washington; an Associate of the Council of New York University; a Fellow of the American Academy of Arts and Sciences; and a member of the National Academy of Sciences and of the National Research Council.

Carty's intense devotion to the National Academy of Sciences and the National Research Council was typical both of his broad interests and of his penetrating understanding of the power existing in institutions founded solidly on a broad base properly related to its surroundings. That he enjoyed the intellectual and personal contacts which these associations afforded was self-evident. They were, however, secondary to his interest in the continuing constructive influence which the Academy and Council could exert on the proper development of the nation. He gloried in the simple national charter of the Academy because he saw in it an instrument of great power. He was disdainful of all that savored of making the Academy merely a home for established scientific reputations—it could hardly escape being that but in his eyes it must be a tool by which science could aid the nation to a better way of living.

With the passing of Dr. John J. Carty on December 27, 1932, the telephone industry lost its foremost artificer and seer, the engineering fraternity one of its keenest minded members, and the American nation a most devoted patriot and champion. The far-flung and highly developed telephone service of the United States today is in large measure the outward embodiment of the imagination and creative power of Carty's mind.

The following honorary degrees had been conferred upon him:

Doctor of Engineering: New York University, Stevens Institute of Technology.

Doctor of Laws: McGill University, University of Pennsylvania.

Doctor of Sciences: Bowdoin College, Princeton University, Tufts College, University of Chicago, Yale University.

For the active part which he took in assisting the U. S. Signal Corps during the war, he was awarded the Distinguished Service Medal. He also received the Edison Medal of the American Institute of Electrical Engineers; the Franklin Medal of the Franklin Institute; the John Fritz Medal; and the Edward Longstreth Medal.

A list of his published writings and addresses is given in the following appendix.

APPENDIX

LIST OF JOHN J. CARTY'S PUBLISHED WRITINGS AND ADDRESSES

Interview, "The Telephone: An Improved Switchboard Introduced by the New England Co." Boston Daily Advertiser, Feb. 22, 1885.

"The Multiple System of Switchboards." Paper presented before the National Telephone Exchange Association, Sept. 10, 1885. Proceedings, National Telephone Exchange Association, 1885; Electrical World, Sept. 19, 1885.

Editorial, "The Danger of Gas in Underground Work." Electrical Review, N. Y., Feb. 9, 1889.

Editorial, "Security Against Disturbances of Ships' Compasses. The Effect of Electric Light Apparatus on Ships' Compasses." Electrical Review, N. Y., June 22, 1889.

Letter to the Editor of the Electrical Review, "Long Distance Telephoning—Electric Cars." Electrical Review, N. Y., Aug. 31, 1889.

Editorial, "The King of Spain and the Exposition." Electrical Review, N. Y., Aug. 31, 1889.

"The New Era in Telephony." Paper by J. J. Carty, A. S. Hibbard and F. A. Pickernell, presented before the National Telephone Exchange Association, Sept. 1, 1889. Proceedings, National Telephone Exchange Association, 1889; Electrical World, Sept. 21, 1889.

"A New View of Telephone Induction." Paper presented before the Electric Club, N. Y., Nov. 21, 1889. Electrical Review, N. Y., Nov. 30, 1889; Electrical World, Nov. 30, 1889.

"Telephone Engineering." Paper presented before the New York Electrical Society, May 15, 1890. Electrical Review, N. Y., May 24, 1890.

"Bridging Bells." Paper presented before the National Telephone Exchange Association, Sept. 10, 1890. Proceedings, National Telephone Exchange Association, 1890.

"Inductive Disturbances in Telephone Circuits." Paper presented before the American Institute of Electrical Engineers, Mar. 17, 1891. A.I.E.E. Transactions, Vol. 8, p. 99.

"The Prophet's Column." Articles appearing anonymously in the Electrical Review, N. Y., from Apr. 4 to Nov. 21, 1891.

Editorial, "Progress in Telephony," and article, "Moving a Telephone Exchange." Based on an interview with J. J. Carty. Electrical Review, N. Y., July 4, 1891.

"Sun Spots and the Weather." Editorial article reviewed by J. J. Carty. Electrical Review, N. Y., July 4, 1891.

"Is Electricity Related to Nervous Force?" Electrical Review, N. Y., Feb. 20, 1892.

"The Common Battery System." Address before the New York Electrical Society in 1902. Electrical Review, Feb. 22, 1902.

"Telephone Engineering." Paper presented before the American Institute of Electrical Engineers, Feb. 23, 1906. A.I.E.E. Transactions, Vol. 25, p. 81.

Talk before the Nashville Telephone Society, Nashville, Tenn., May 18, 1909. Cumberland Telephone Journal, June, 1909.

Address before the New England Telephone Society, June 14, 1910. New England Telephone Topics, June, 1910.

"Telephone Service in America." Address before the International Conference of European Telephone and Telegraph Administrations, held at the Sorbonne, Paris, Sept. 4-11, 1910. Proceedings, International Telephone and Telegraph Conf., Vol. 1, p. 157; Electrical Review, N. Y., Oct. 15, 1910.

"Long Distance Telephony." Address before the International Conference of European Telephone and Telegraph Administrations, held at the Sorbonne, Paris, Sept. 4-11, 1910. Telephone Engineer, October, 1910; Electrician, London, Oct. 21, 28, Nov. 4, 11, 1910.

"Long Distance Telephony in America." Paper read at the Second International Conference of Telephone and Telegraph Administrations, held in Paris in 1911. Telephone Engineer, March, 1911.

"Philadelphia and the Development of the Telephone." Paper read before the Philadelphia Section of the National Electric Light Association, March 18, 1912. Current News, April, 1912.

"Pioneer Engineering." Address at the Second Annual Convention of the Telephone Pioneers of America, N. Y., Oct., 1912. Proceedings, Telephone Pioneers of America, 1912.

Statement on the opening of the transcontinental telephone line, New York to San Francisco, Jan. 25, 1915. Telephone Review, Triumph of Science edition.

"The Status of the Engineer." Paper read at the Symposium at the Convention of the American Institute of Electrical Engineers, Feb. 17, 1915. A.I.E.E. Transactions, Vol. 34, p. 327.

Address at the presentation of the Edison Medal to Dr. Alexander Graham Bell, May 18, 1915. A.I.E.E. Pamphlet.

Address as President of the American Institute of Electrical Engineers at the banquet of the International Engineering Congress, San Francisco, Sept. 24, 1915. A.I.E.E. Transactions, Index Volume, p. 104.

Interview, in the San Francisco Bulletin, October 5, 1915, on the occasion of the radiotelephone demonstration.

Interview, in the Chicago Herald, October 24, 1915, on the occasion of the radiotelephone demonstration.

Address at the dinner in his honor at the Lotos Club, N. Y., Nov. 27, 1915. Published in "Modern Eloquence" volumes.

"The Outlook for the Work of the A.I.E.E." Electrical World, Jan. 1, 1916.

Address at the dinner of the National Geographic Society, Washington, D. C., Mar. 7, 1916. National Geographic Magazine, March, 1916.

Address before the New England Telephone Society, Apr. 19, 1916. New England Telephone Topics, May, 1916.

Address at the banquet of the Boston City Club, April 20, 1916. New England Telephone Topics, May, 1916.

Communication, as President, to the membership of the American Institute of Electrical Engineers, April 20, 1916, on the subject of industrial preparedness for national defense. Printed by the A.I.E.E. in letter form.

Address at the National Meeting of the American Institute of Electrical Engineers held simultaneously in New York, Boston, Philadelphia, Atlanta, Chicago and San Francisco, by means of the long distance telephone, May 16, 1916. A.I.E.E. Proceedings, Vol. 35, Pt. 1, p. 139; Telephone Review, June, 1916.

"The Telephone Art." Address before the Franklin Institute, Philadelphia, upon receiving the Franklin Medal, May 17, 1916. Journal, Franklin Institute, Vol. 182, p. 89; Telephone Review, June, 1916.

Address at the dinner in his honor by the Regents of the University of the State of New York, Albany, May 24, 1916. Elmira Telegram, June 5, 1916.

"The Relation of Pure Science to Industrial Research." Address as retiring President of the American Institute of Electrical Engineers, June 27, 1916. A.I.E.E. Transactions, Vol. 35, Pt. 1, p. 479; Science, Oct. 13, 1916.

Interview, by Henry N. Hall, New York World, July 23, 1916: "From Earth to the Far-away Planets by Wireless Phone."

"The Extension of the Spoken Word." Address at the 52nd Convocation of the University of the State of New York, Oct. 20, 1916. Proceedings of the 52d Convocation of the University of the State of New York, Albany, Oct. 19, 20, 1916, p. 196.

"The Wireless Telephone of the Future." A study of Chief Engineer John J. Carty, in the New York World. Telephone Engineer, November, 1916.

Address at the presentation of the Civic Forum Medal to Dr. Alexander Graham Bell, N. Y., Mar. 21, 1917. Telephone Review, May, 1917.

Address, July 25, 1917, at Camp Alfred Vail, before the 1st and 2d Telegraph Battalions, prior to their departure for France. Telephone Review, September, 1917.

Address, Oct. 8, 1917, at the Downtown Club, Newark, N. J., before the members of the 3d Telegraph Battalion. Telephone Review, November, 1917.

Address before the American Institute of Electrical Engineers, upon receiving the Edison Medal. A.I.E.E. Proceedings, June, 1918; Telephone Review, June, 1918.

"Pure Science and Industrial Research." Address at the joint meeting of the American Institute of Electrical Engineers and the American Physical Society, Philadelphia, Oct. 10, 1919. Abstract in A.I.E.E. Journal, Vol. 39, Pt. 1, p. 57.

Address at the New York Electrical League luncheon, N. Y., Nov. 12, 1919. New York Evening Sun, Nov. 12, 1919.

Statement before the Committee on Military Affairs, House of Representatives, 66th Congress, 2d Session, Jan. 28, 1920. Printed by the Government Printing Office, 1920, "Army Reorganization—Signal Corps, Hearings . . ."

"Science and the Industries." Address under the auspices of the National Research Council, Washington, D. C., Feb. 6, 1920. National Research Council Reprint and Circular No. 8.

Address at the Eighth Meeting of the Telephone Pioneers of America, St. Louis, Oct. 24, 1921. Proceedings, Telephone Pioneers of America, 1921.

"World Electrical Communications." Address before the Philadelphia Forum, Mar. 8, 1922. Philadelphia Ledger, Mar. 9, 1922; Telephone and Telegraph Age, Apr. 1, 1922.

"The Telephone's Development." Abstract of Verbal Testimony before the New York Public Service Commission, Albany, Mar. 15, 1922. Bell Telephone Quarterly, April, 1922; Telephony, Mar. 25, 1922; Literary Digest, Sept. 30, 1922.

"Achievements in Telephony." Address before the Harrisburg Radio Association, Apr. 6, 1922. Telephone News, May, 1922.

"Ideals of the Telephone Service: A Tribute to the Memory of Alexander Graham Bell." Presidential address at the Ninth Meeting of the Telephone Pioneers of America, Cleveland, O., Sept. 29, 1922. Proceedings, Telephone Pioneers of America, 1922. Bell Telephone Quarterly, October, 1922.

Address at the dinner to Assistant Secretary of War Wainwright, N. Y., Feb. 20, 1923. Information Bulletin No. 22, Office of Chief Signal Officer, Oct. 1, 1923.

"World Communications." Address before the Commercial Club of Chicago, Mar. 9, 1923. Public Service Management Magazine, April, 1923; Telephony, Mar. 17, 1923.

"Electrical Communications." Address at the meeting of the Transportation and Communications Section, United States Chamber of Commerce, N. Y., May 8, 1923. Pamphlet published by the United States Chamber of Commerce.

Address at the presentation of the Franklin Medal to General G. Ferrie, Inspector-General of Military Communications in the French Army, May 16, 1923. Journal, Franklin Institute, December, 1923.

Interview, by Merle Crowell, American Magazine, August, 1923: "Are You a Wishful Thinker?"

Address at the celebration of the 40th Anniversary of the American Institute of Electrical Engineers. A.I.E.E. Transactions, Vol. 43, p. 114.

Address at the Industrial Preparedness dinner, N. Y., Feb. 5, 1924. Army Ordnance Magazine, March-April, 1924.

Address at the dinner of the Bond Men's Club of Chicago, Feb. 8, 1924. The Ohio Bell, April, 1924; Radio Broadcast, May, 1924.

"Science and Business." Address before the United States Chamber of Commerce, Cleveland, O., May 8, 1924. National Research Council Reprint and Circular No. 55; The Transmitter, June, 1924; The Ohio Bell, June, 1924.

"Triumph of the Telephone." Electrical World, Sept. 20, 1924.

Address at the "Radio" Luncheon of the Merchants Association, N. Y., Feb. 17, 1925. Bulletin of the Merchants Association entitled "Greater New York," Feb. 23, 1925.

"The Telephotograph as an Aid to the Police." Address at the International Police Conference, N. Y., May 13, 1925. Proceedings of the 1925 Meeting of the International Police Conference, N. Y., May 12-16, 1925.

"The Semi-Centennial of the Telephone." Bell Telephone Quarterly, January, 1926; Telephony, Jan. 30, 1926.

"Episodes in Early Telephone History." Address at the luncheon of the Boston Chamber of Commerce, Mar. 11, 1926. Bell Telephone Quarterly, April, 1926; Telephone Topics, April, 1926.

Address at the Boston City Club, Apr. 15, 1926, on the 50th anniversary of the Invention of the Telephone. Telephone Topics, May, 1926.

Address at the dinner of the Algonquin Club, Boston, June 3, 1926, celebrating the establishment by Boston University of the Alexander Graham Bell Foundation to endow a Chair of Speech. Boston Evening Transcript, June 4, 1926.

Letter of appreciation written upon the occasion of the death of Charles E. Scribner. Western Electric News, August, 1926.

"Communication." Address at the 12th Session of the Congress of American Industry, Philadelphia, Sept. 15, 1926. Congress of American Industry: Discussion of Leading Authorities, Sept. 7-27, 1926.

"Procurement of Signal Communication Supplies for Military Purposes and its Relation to Industry." Military Signal Communications, Vol. I, No. 1, May, 1927, p. 6.

"Ideals of the Engineer." Address upon receiving the John Fritz Medal, Feb. 15, 1928. Science, Mar. 23, 1928; Bell Telephone Quarterly, April, 1928.

Presentation speech at the presentation of the Gold Medal of the National Institute of Social Sciences to Dr. Willis Rodney Whitney, May 3, 1928. Journal, National Institute of Social Sciences, Vol. 13, Nov. 15, 1928, p. 29.

Foreword to "Beginnings of Telephony" by Frederick L. Rhodes. Published by Harper and Brothers, New York, 1929.

"Peace and Plenty through Science." Introduction to Vol. 3 of Research Narratives, published by the Engineering Foundation, New York, 1929.

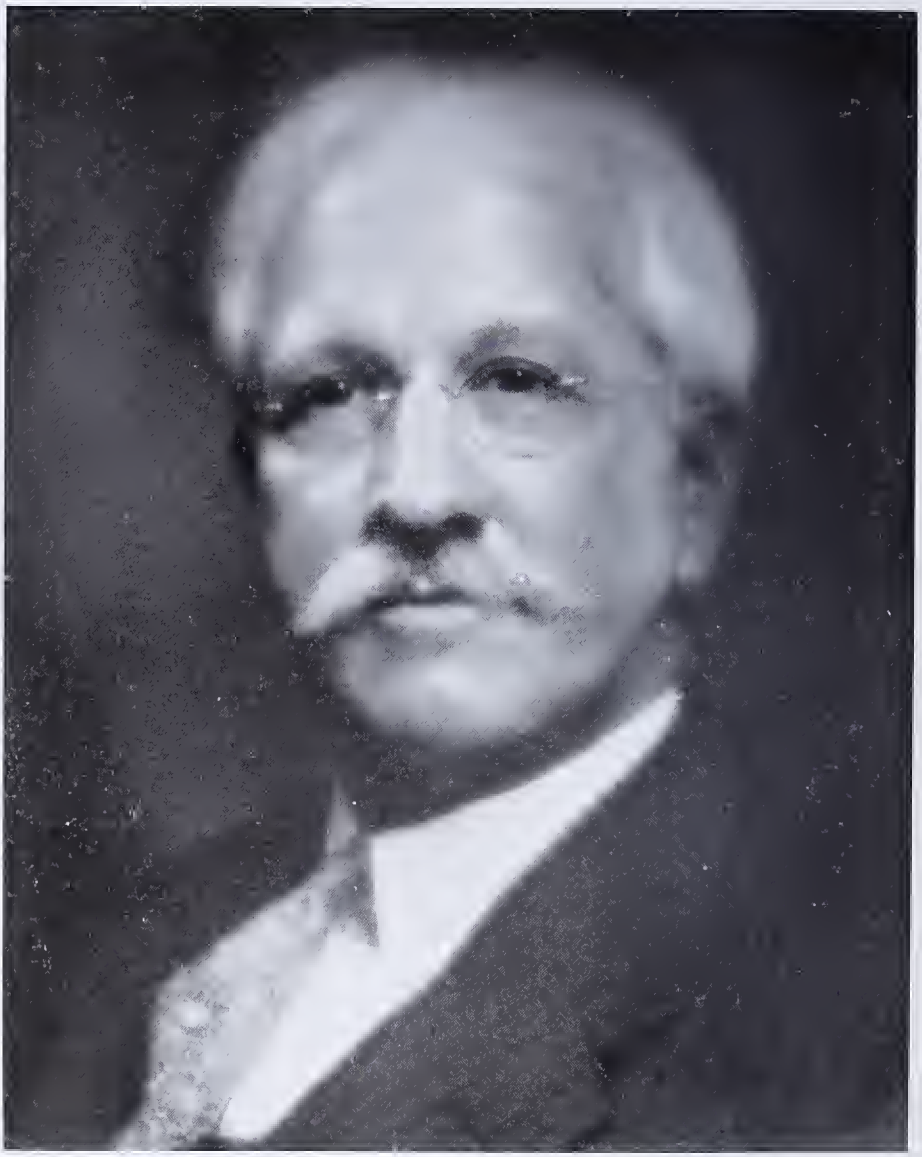
Address at the presentation of the Edison Medal to Dr. Frank B. Jewett, Jan. 30, 1929. A.I.E.E. Pamphlet "Presentation Ceremonies at the Winter Convention of the American Institute of Electrical Engineers, New York, Jan. 30, 1929."

"The Mission of the Engineer." Address at the presentation of the John Fritz Medal to President Hoover, Apr. 25, 1929. Printed in book "John Fritz Medal Presentation to Herbert Hoover, 1929," issued by the John Fritz Medal Board of Award.

"Science and the Social Organism." Address, as a member of the Board of Trustees, on the 25th anniversary of the initiation of research in the Carnegie Institution of Washington, May 31, 1929. Year Book of the Carnegie Institution of Washington, 1929; Science, Vol. 69, June 7, 1929, p. 590.

"Science and Progress in the Industries." Address at the Convention of the National Electric Light Association, Atlantic City, June 5, 1929. Electrical World, June 8, 1929.

"Science, the Soul of Prosperity." Article in the Review of Reviews, June 5, 1929, based upon the address at the Convention of the N.E.L.A.



James H. Breasted

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OF

JAMES HENRY BREASTED

1865–1935

BY

JOHN A. WILSON

PRESENTED TO THE ACADEMY AT THE AUTUMN MEETING, 1936

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JAMES HENRY BREASTED
1865–1935

BY JOHN A. WILSON

INTRODUCTION

James Henry Breasted was the first American whose profession was ancient history. In that fact reside the corollaries that the times were ripe for such a study and that this man shaped the course of the study. These statements do scant justice to a man whose presentation of material carried his influence beyond the limits of college halls and made him a figure of international significance. He brought to America the realization that our cultural ancestry is rooted in the distant past and made European scholars aware of the peculiar contribution which American scholarship might make to humanistic research.

Although he was essentially an historian and his life was devoted to a study of the "career of man," he insisted that this study could not be divorced from the data presented by the physical and natural scientists. He gave active support to research in geology and palaeontology, in order that the story of man's sojourn on this planet might be as complete as possible.

FAMILY DATA

The Breasted line runs back to the Netherlands and thence ultimately to Denmark. The first record of the family in this country is in 1647, when Jan van Breestede was in New Amsterdam. This Dutch stock united with English stock, and a branch of the family moved west until Breasted's father Charles, settled as a hardware merchant in Rockford, Illinois.

In this town, about 80 miles northwest of Chicago, James Henry Breasted was born on August 27, 1865. The Midwest town and the period following the Civil War were important factors in shaping his outlook on life.

In 1894 he married Frances Hart, of Oakland, California. Their three children are Charles, James Henry, Jr., and Astrid.

Mrs. Breasted died in 1934. He married Imogen Hart Richmond, sister of his first wife, in 1935.

His death in New York City on December 2, 1935, was due to a hemolytic streptococcic infection contracted as he returned from a trip to the Near East.

THE STUDENT PERIOD, 1888–1894

Breasted received his B.A. at North Central College (then North-Western College) at Naperville, Illinois, in 1888. The necessity for earning a part of his way through college and seminary set him at a number of tasks, such as working in a pharmacy. Essential to his early background was the belief that learning was highly prized, but it was also highly priced and one must work hard to gain it.

The young man was destined for the Congregational ministry and went on from college to the Chicago Theological Seminary. His family life had been strongly religious in a quiet assurance. The teachings of the seminary did not harmonize with Breasted's ideas on theology and doctrine. He did not complete the course. However, a new interest had been awakened. As a small boy he had been fascinated by the illustrations in Layard's "Discoveries among the Ruins of Nineveh and Babylon." Now the study of Hebrew revived some of the small boy's excitement over a distant world. He went to Yale University in 1890 for graduate study in the Hebrew language.

Yale was a stimulating place because of the electric personality of William Rainey Harper, who had a new and interesting method of teaching Hebrew, and who was later to become the first president of the University of Chicago. In this environment at New Haven, Breasted's career took its definite shape. In 1892 he received his M.A. With the encouragement of Harper, he went to Europe for study in Egyptian.

It should be pointed out that in 1892 Oriental studies—with the exception of Hebrew for Old Testament work—were almost unknown in the United States. Scientific excavation had just begun, but the antiquity-hunter and the dilettante were still very

much in the field. The Egyptian hieroglyphs had been deciphered 70 years earlier, but there was still no orderly presentation of the Egyptian language in any text-book. Cuneiform studies were in essentially the same incoherent state. Translations were often intuitive rather than controlled by grammatical rule. Almost every history of the ancient Orient had its orientation in the Biblical and classical sources instead of using the increasing amount of original material. A few men had gained a greater mastery over their material, but they had not yet committed it to writing.

All of the progress which had been made up to 1890 was the product of European scholarship. Americans were aware of the new technique of excavation just introduced by the Englishman Petrie, of the brilliant historical writing of the Frenchman Maspero, of the grammatical studies of the Germans Delitzsch and Erman. But as yet there was no instruction in these lines in the United States, as no Americans were competent to teach the new disciplines.

Americans had been further removed from the European and Oriental scene and were preoccupied in making their own history, looking toward the future rather than the past. Interest in the past was firmly rooted in the Bible and in the Greek and Roman classics. Now the nation was more mature and could cast a reflective glance backward. It had reached its geographical boundaries and was conscious of a larger world. It is significant that Breasted was not the only American who went to Europe in the '90's to study ancient history.

As Yale had been an exciting place under the influence of Harper, so the University of Berlin was stimulating under the influence of Adolf Erman, the genial young Egyptologist. He was bringing the Egyptian language into scientific form and had just published a most satisfactory study of life in ancient Egypt. The brilliant group of young students attracted to his seminars was no less animating. There were days of intense study in an air electric with new ideas. There were occasional evenings of that whimsical geniality which the serious German student permits himself. The young man from a midwest town was drawn

into an entirely new world, in which he found himself able to compete on his own merits.

In 1894 he received his Ph.D. from the University of Berlin, writing a Latin dissertation on certain hymns of Akhenaton, the Egyptian heretic pharaoh. He became Assistant in Egyptology at the new University of Chicago.

THE RESEARCH PERIOD, 1894–1907

From 1894 until 1925 Breasted taught Egyptian at the University of Chicago, advancing from Assistant to the rank of Professor of Egyptology and Oriental History by 1905. During the first decade of his teaching pupils were few and far between. He was the only teacher of Egyptian in the country and was relatively unknown. To spread the gospel of his subject and to supplement his meager salary he traveled extensively in the United States giving popular lectures. The young scholar turned into the fluent interpreter.

During this first decade President Harper allowed him generous leaves of absence to pursue his work in Europe and Egypt. All this traveling was a serious drain on a temperament so taut. Throughout his active career he suffered severe attacks of indigestion. That same driving force which subjected him to these protracted attacks carried him through them to complete work which he wanted to do. When he took an arduous trip up the Nile in 1905-06 his doctor forbade him to travel without a physician in attendance. Breasted could not afford such a luxury, took the trip anyhow, and worked long every day under trying conditions. It is characteristic of him that when he was suffering severely at a later time he said: "I cannot walk . . . to my office . . . but I am going to Egypt, if I go on a stretcher!"

It has already been stated that the era of intuitive and individualistic Egyptologists was drawing to a close and that discipline was being introduced into the young science. Two corollaries of this were that co-operative activity was necessary to establish the new régime and that the existing documents must be re-examined in the light of a better understanding. None of

the new school was willing to take an old copy or an old translation at its face value. They wanted to make their own first-hand copies and translations. The notation "verified by my own collation" was essential to the final study of any document.

In 1897 the Royal Prussian Academy of Sciences, with the assistance of the German government and the personal interest of the Emperor, began a dictionary of the ancient Egyptian (hieroglyphic) language. Individual scholars had compiled small glossaries before. This was to be a "complete" dictionary on historical principles, fully documented with references. Texts were to be copied and analysed by the most competent scholars. The work is still in process, now well into the publication stage.

Breasted became associated with this project and spent the years 1899-1901 traveling about Europe to make careful copies of the inscriptions in various museums. He was on a limited budget, so that it was not an easy period. But every week brought some new discovery, and that was compensation for a great deal of discomfort. Parenthetically, it might be noted here that the dictionary reached its publication stage in the 1920's. Germany was then a republic; there was no emperor to promote so learned a project. It was Breasted who called the dictionary to the attention of John D. Rockefeller, Jr., so that the volumes might be published in satisfactory form.

Along the course of the Nile River there are hundreds of inscribed temples and tombs, documents on the history of Egypt. Many of these had been copied in the nineteenth century. In view of the conditions limiting this earlier copying, it is no real disparagement to state that it was incomplete, haphazard, and lacking in linguistic competence. Year after year these monuments lose value, as they are exposed to water, weather, and vandalism. It is essential that they be recorded with care. Modern copyists have two great advantages over their predecessors: portable, rapid cameras and a much better understanding of Egyptian.

Breasted conceived the idea of copying *all* the monuments of ancient Egypt. It was a titanic project, characteristic of the man and of the University of Chicago at the time. The Univer-

sity of Chicago made no commitment to Breasted on the complete project, but he spent the two years 1905-06 and 1906-07 in recording the monuments of Nubia and the Sudan.

Those two years were difficult and adventurous. Breasted, his wife and son, with a photographer and a copyist, spent much of the time on small native boats, harried by local incompetence, plagues of gnats, weeks of sandstorms. Once they were shipwrecked in the Third Cataract, and it seemed that the entire season's work might be lost. When they finally emerged into calmer waters they carried a record of the historical monuments of pharaonic times along 1200 miles of river. It was an heroic undertaking.

President Harper had died in 1906, and the University of Chicago was facing a period of retrenchment. The ambitious plan to copy all the monuments of Egypt had to be abandoned, to be revived in modified form twenty years later. Breasted returned to his academic duties in Chicago.

THE PERIOD OF INTERPRETATION, 1905-1919

During the decade following 1894 Breasted was concerned chiefly with ancient Egyptian texts. His interest, however, was not in the linguistics of inscriptions but in their historical content. In 1906-07 he completed a colossal task by publishing translations of all the historical inscriptions of ancient Egypt down to the Persian period, 525 B. C. In view of the magnitude of the task the translations are very good, and the work is in daily use today. A characteristic feature of the study is its insistence on first-hand acquaintance with the inscriptions, whether by personal collation or the use of photographs.

These *Ancient Records of Egypt* were also the source materials for a connected account in *A History of Egypt,* published in 1905. This is still the best book on the subject, even though it lacks the results of the past thirty years of research. Breasted was planning a complete rewriting of the volume at the time of his death. The history was based directly on the *Ancient Records,* thus permitting the Egyptians to speak for themselves.

The book was scholarly and authoritative, but what lifted it out of the category of other histories was its charm. Breasted's style was lucid and attractive, and he wrote with a verve and enthusiasm which were infectious. Without distorting the facts presented, he exhibited the Egyptians as a people worthy of warm admiration and their career as a romance. The work loses considerably in attractiveness in its later chapters, which tell the story of an Egypt which had no longer an upward lifting force. Here the author's enthusiasm is not so keen. Despite that, there has been no better writing, even by Breasted himself.

The publication of the *Records* and the *History* made the young scholar a more widely known figure. His "barnstorming" lecture trips had laid the foundation for an understanding of his *History*. In the dozen years preceding 1905 successful and spectacular excavations had aroused an extraordinary interest in ancient Egypt. Breasted was already known to the European scholars. They received his new works cordially. It is significant that the translations of the *History* into French and German were made or supervised by Egyptologists of standing.

Breasted was now teaching the general course in Ancient History at the University of Chicago, and was gaining an acquaintance with materials from fields other than Egypt. His success in presenting this survey to graduate and undergraduate students moved a publishing firm to request him to write a high school text book on ancient history. Breasted refused with definiteness. He was an Egyptologist and claimed no authoritative competence in all branches of ancient history. He had no experience in presenting material to the high school mind. The publisher kept returning insistently, until finally Breasted agreed. The result was a collaboration in 1914 with James Harvey Robinson on a general history of Europe, with Breasted covering the period from earliest pre-historic times to the fall of the Roman Empire.

This work prepared the way for the high school text book, *Ancient Times,* published in 1916. Breasted told his story in

simple and vivid terms and gave a great deal of attention to the illustrations. Nearly 300 illustrations and 50 maps and plans help to explain the popularity of the book. It received the accolade of an enthusiastic review by Theodore Roosevelt in the *Outlook* and was soon in extensive use in schools throughout the country. It is difficult to measure the influence of such a book, but it is probably true that it was responsible for the creation of the Oriental Institute because it presented Breasted to a very wide public as America's foremost ancient historian.

From such a standpoint *Ancient Times* was Breasted's greatest work. For the scholarly world he was engaged in other, more important research. In 1912 Breasted was invited to give a series of lectures under the Morse Foundation at Union Theological Seminary in New York. For reasons which will be indicated below he chose as his subject "Religion and Thought in Ancient Egypt." The seminary students and the general public attending these lectures were disappointed. They had heard that Breasted was a brilliant lecturer and lucid expositor. They found the lectures slow, apparently repetitious, and heavily documented. They were unaware that Breasted was doing an exciting piece of pioneering, that he was presenting most important material for the first time. It was necessary for him to emphasize and document every step of his argument. It was only after the lectures were published as *Development of Religion and Thought in Ancient Egypt* that their full importance was appreciated.

Ever since he published his doctor's dissertation on hymns of the heretic pharaoh Akhenaton, Breasted had been persuaded that there was progress in ancient Egyptian thought and that the Egyptians had made major contributions to the philosophy and moral feeling of mankind. No book on Egyptian religion took account of the fact that religion might be a changing, progressing force. The books were either catalogues of the gods, with the confusions and contradictions inherent in 3000 years of history, or they presented separate periods of Egyptian religion without any connection or causation. Egyptian religion when thus presented was so diverse and remote that it was

taken by all sorts of crank doctrines and weird cults as their ancestral origin. It still has the same appeal to the cabalistically minded, but now Breasted's work stands as a bulwark against such nonsense.

In 1908-10 a body of Egyptian religious texts was published in hieroglyphic manuscript. They were texts inscribed in Old Kingdom pyramids and constituted the earliest large body of religious material available anywhere. Breasted translated these texts with care and saw their significance. Egyptian religion could be shown to be a progression from a materialistic and timorous attitude to a moral and reverent attitude toward deity and toward the good life. From earliest times to a period when the Hebrew nation was taking significant form, the development of moral thought in Egypt was a logical progress and a romantic chapter in man's life. This was the message which he laid so painstakingly before the seminary students.

It is easy to criticize Breasted's presentation as it appeared in *Development of Religion and Thought* and later in *The Dawn of Conscience.* He emphasized the rôle of Egypt in the development of human morals to such an extent that he antagonized three groups: those who were interested in the claims of other ancient civilizations, those who felt that Egypt was a phenomenon remote from the course of western history, and those who were so firmly rooted in the Bible that they felt that other developments were meaningless, derived, or tributary. Breasted was always firmly persuaded of the important rôle which Egypt had played. He was eager to admit the contributions made by other civilizations, except where they might compete with Egyptian claims. There he felt that the facts clearly demonstrated Egypt's priority. He was willing to concede that other men had a right to their contrary opinion, and he would assist them to publish that opinion, but he felt a little discouraged that they could not see the light of Egypt as brilliantly as he.

Another criticism which might be leveled against the *History of Egypt* and the *Development of Religion and Thought* is that they emphasize the glorious early progress of the Egyptians and devote correspondingly less attention to the fact that Egypt

finally degenerated into a sterile and spiritless unimportance. Part of the history of the people is their woeful slump from the heights. Breasted's answer would probably be that he wanted to show the heights that man might attain, that "the processes which brought forth inherited religion have never ceased, that they are going on around us every day, and that they will continue as long as the great and complex fabric of man's life endures." This was his matured philosophy, and this theme recurs through all his later writings.

Many of Breasted's later writings were modifications of works already discussed. *The Conquest of Civilization* (1926) retells the story told in *Ancient Times* for the more mature reader and adds important new material. *The Dawn of Conscience* (1933) is a reworking of *Development of Religion and Thought* in terms which would reach a wider public. This book, the product of a man approaching his three score years and ten, is profoundly significant. Breasted had a conviction that man could and would rise. He was troubled that the world should be so torn by doubts and suspicions. He was sure that social and economic "tinkering" did not go to the heart of the problem, that a knowledge of man's moral potentialities was fundamental to an attack on our difficulties. Moderns must not be dismayed by world problems, they must not doubt; they must have confidence in man, so that they may begin a recreation of the world. The very earnestness of the book robbed it of that *élan* which had been so charming in his earlier works. Nevertheless, it is an important *credo* by a great humanist.

In the spring of 1919 Breasted gave a significant series of lectures before the National Academy of Sciences in Washington, under the William Ellery Hale Foundation. These lectures were published as "The Origins of Civilization" in *The Scientific Monthly*. Beginning with the Old Stone Age, the argument ran down into historic times, showing the stream of human progress from savage man to the highly developed Oriental cultures. The Egyptologist had branched out and was here making a formal statement on the place of all ancient civilization in the course of human history. This was significant in color-

ing the later work which Breasted was to do in founding the Oriental Institute, which was not an institution to study Oriental languages or civilizations, but was to be a "laboratory for the investigation of the early human career," tracing the rise of man from the savage to the moral and intellectual being.

Two general criticisms have been leveled at these lectures, criticisms which apply to all of Breasted's later work. A minor objection might be raised to Breasted's pro-Egyptian bias, as in the statement that "western Asia was far behind Egypt at the opening of the fourth millennium B. C." This is a controversial matter. It is certainly not as simple as Breasted states it, and a good case may be worked up for the priority of Babylonian civilization. However, part of Breasted's success lay in the fact that he believed in Egyptian priority and was able to make it a simple and appealing fact to others.

A more serious criticism which might be directed against Breasted's philosophy of history is its optimism. The story told in the lectures might easily lead to the naive conclusion that man's progress is automatic. Breasted had no such idea; he told the story simply and in enthusiastic terms, which might be misinterpreted. We shall return again to the discussion of his sanguine views on human history.

Breasted had a youthful buoyancy, and he greatly enjoyed his contacts with young people. In years when his administrative duties were urgently pressing, his secretary was troubled that he gave so much time to interviews with students. He always wanted to see them, if only to give them a friendly warning that Oriental studies were hazardous as a career. His classes were a pleasure to students and teacher. His course in ancient history was easy even for an undergraduate, as he held closely to the broad central channel and avoided those disturbing little eddies which present problems to helmsman and crew. If his students thus lost a training in historical method and discipline, they carried away a lasting memory of an inspiring story. It was more important to Breasted that they should have some of that high vision than that they should be trained in the critical analysis of source material. The former

he held to be fundamental to a general survey course, or even to the interpretation of a text, the latter was more a matter for advanced graduate study.

His courses in grammar and translation were equally invigorating. His linguistics were sound, and he could make grammar interesting as an aspect of the mind of man. He was, however, chiefly interested in the content of texts as historical material. It was very easy for a student poorly prepared to drop a question or two and prompt an hour's exposition of some historical point. His pupils carried away three important convictions: grammar is not an end in itself but is a key to the understanding of ancient man; it is essential to have a commanding control over this key; every document from an ancient civilization puts the translator in intimate touch with a vital personality from the past. If they were thus armed, Breasted felt that he could count on them to deal with their material creditably.

THE PERIOD OF ORGANIZATION, 1919-1935

The advance of the growing field of Oriental studies brought greater specialization in the various branches. Too often this specialization meant isolation, with limited funds and insufficient knowledge of related branches. Breasted's work on the Egyptian Dictionary had shown him the value of co-ordinated effort. A group of scholars working in community produces more than the sum of individual studies, because of the interplay of ideas and the synthesis of results.

In the early years of the twentieth century Breasted was working on plans for some type of organization in which scholars would be working together, free from financial worries. One such plan, when he proposed to copy all the historical monuments of pharaonic Egypt, provided for a "floating laboratory," a houseboat on the Nile equipped with living quarters, library, and dark room. A more ambitious plan proposed the essentials of that institution later realized in the Oriental Institute. It called for expeditions in Egypt, Syria-Palestine, and

Mesopotamia. The budgets proposed for these expeditions were, by modern standards, absurdly low. It is a question whether final answers to problems could be given by expeditions operating on such tight financing. However, it must be recognized that in 1902 expeditions were not "scientific" in the sense of 1920, that the post-war technique has made a fundamental difference so that archeology is now a profession for specialized technicians, instead of being an avocation for teachers and men of means.

These early proposals did not reach realization. The University of Chicago had its own financial problems, and the remarkable first decade of expansion made caution necessary. Possible donors were not persuaded of the ultimate value of archeology. One of them commented that the Bible would stand without the aid of archeology. This is entirely true, but it reflected the narrower convictions of the nineteenth century. Breasted did not cease his efforts to enlist interest, until the war intervened and put a halt to such possibilities.

His philosophy in approaching possible patrons was that he was not a client soliciting funds from a man of means but had alluring opportunities which any intelligent person would desire to embrace. This was easy for a man who was such an enthusiast convinced of the permanent value of his work. The approach was particularly effective in the 1920's when Americans were seeking opportunities for their funds.

The period following the Great War was one which offered American scholars a brilliant chance. Europe was exhausted, both financially and spiritually. America was prosperous and alert for opportunity. The Near East was freed of the incubus of the old Turkish state and lay open to research under a series of friendly mandates and states. Archeology had been the preserve of a small number of European scholars. The interval of the war and an insistence on technology in archeology opened up the field to new scholars who could compete on an equal footing with the old. The time was ripe for a major attack on the ancient Orient.

In the spring of 1919 Breasted wrote to Mr. John D. Rockefeller, Jr., calling attention to America's opportunity under these conditions. Mr. Rockefeller replied cordially promising $10,000 a year for five years. On this slender basis the Oriental Institute was launched, "to trace as fully as possible the rise of man from Stone Age savagery through successive stages of advance, the emergence of civilization, the history of the earliest great civilized states, and the transmission to Europe of the fundamentals of civilization which we have since inherited."

The history of that Institute will be sketched only briefly here. It is a story which Breasted himself told brilliantly in *The Oriental Institute* (1933). The story of the Institute up to the present falls into four periods: 1919-25, experimentation; 1925-28, expansion; 1928-36, realization; and 1936-, retrenchment.

In 1919-20, Breasted, his Assyriological colleague Luckenbill, and three young scholars made a daring reconnaissance trip through the Near East to survey the possibilities for research work. Crossing territory which was still virtually in a state of war, they emerged with an enthusiasm for the possibilities apparent in the Oriental field. The following years saw a gradual growth, with the establishment of such projects as an epigraphic survey to copy the monuments of Thebes in Egypt and the Assyrian Dictionary, a project comparable to the Egyptian Dictionary already mentioned.

In the period 1925-28 increasing possibilities resulted from the support of the General Education Board. New expeditions were launched in Palestine, Egypt, Anatolia, and Iraq. The development of the Institute reflected the buoyant period in American finances.

The same statement applies to the action taken in December, 1928, by the Rockefeller boards. New funds provided for the erection of an Oriental Institute building on the campus of the University of Chicago, for a teaching endowment, and for a ten year period of research and publication. The Institute was thus enabled to go ahead on a scale which approximated the vision of James Henry Breasted, its Director. Mr. John

D. Rockefeller, Jr. expressed his interest by supporting three projects personally, and there were several other donors. At one time the Institute had six expeditions in Egypt and six in Western Asia (Palestine, Syria, Anatolia, Assyria, Babylonia, and Iran), in addition to the research carried on at the home headquarters. The Oriental Institute had become the leading archeological institution in the world and the outstanding organization devoted to research in the humanities. A brilliant group of research workers, American and European, formed this organization, but it was invoked by the unaided efforts of Breasted. The leaders of the various projects had considerable independence in administering their own fields, but Breasted was the Director, and ultimate authority was his.

The Institute is at present consolidating its work into a more compact organization. Its finances reflect the year 1935-36 just as truly as its expansion reflected 1928-29. Breasted had seen that a certain retrenchment was inevitable. The world financial situation gave him deep concern and occasioned impassioned outbreaks against those whom he considered responsible for the tightness of money. Fortunately, he saw the Institute at its peak of productivity and success in the autumn of 1935. Death spared him the necessity of reducing the organization which had become the consuming interest of his life.

It should be pointed out that Breasted raised more money for projects outside his Oriental Institute than he did for the Institute. Most notable was Mr. Rockefeller's offer to the Egyptian government of a fully equipped museum and institute, a magnificent proposal for which Breasted was the energetic but unsuccessful diplomatic agent. Many other large and small projects outside his Institute benefited by his ability to enlist the interest of men of means.

The last fifteen years of his life saw him increasingly occupied with administration. In directing the Oriental Institute he had able assistance from his son Charles, but the organization was so large and complex that it demanded the major portion of his time. Yet a glance at the bibliography will show that he did not cease his scientific work. The outstanding technical

product of his later years was the *Edwin Smith Surgical Papyrus* (1930), the translation and study of an old Egyptian medical treatise. From the philological, historical, and scientific aspects the work is excellent. It was done in hours and minutes snatched from a full schedule of administration.

Breasted kept himself under careful control in these later years. The nervous indigestion to which he was prone necessitated a frugal diet and sufficient rest. He retired early of an evening and was at his office before 8:30 in the morning. Neither social engagements nor vacations were permitted to interfere with the work which he wanted to accomplish.

THE MAN

James Henry Breasted represented the best aspects of that spirit which we cherish as the American ideal. He had a buoyancy and a faith which surmounted discouragements and believed in the future. He was born just after the Civil War, and his world outlook matured between that struggle and the World War, a period of moderate liberalism, of optimism, of faith in democracy and in education. The more general features of the theory of evolution became common currency in that time. He grew up in the Middle West, where a cardinal principle was that a man could realize on unlimited opportunities if he only were willing to invest hard work. These influences provided him with a deep faith.

As Breasted's work progressed this faith left conventional religion and became a pronounced humanism. An obvious break was his departure from the theological seminary. But he still retained a strong theistic feeling, until the *Development of Religion and Thought* in 1912 enunciated his belief in man. Thereafter his humanism became more emphatic in his various writings. One of the many phrases which he coined and made current was "the unconquerable buoyancy of the human spirit." This essential characteristic of man was all important. Breasted was untiring in his efforts to show its existence in the past and its importance for the future.

Stripped to its essentials Breasted's argument was this: if we study ancient history from the beginning we see clearly that man's course has followed an upward line through some mysterious lifting force in man. If thousands of years show this progress is it not essential to man? Thus stated, the argument seems simple to the point of naivety. It often seems naive in Breasted's presentation of it. When simplified, it would seem an argument that man's buoyancy will carry him ever higher by automatic process. Certainly Breasted did not mean this. He stressed and underlined man's possibilities in a way which over-simplified, simply because he did not believe that progress was automatic. He felt that it was necessary that modern man know the potentialities inherent in mankind, so that he might realize those potentialities by painful effort. The inspiration of the past was to be a lifting factor for the present and future.

Another of Breasted's telling phrases was "the new past." This implied the new methods and new techniques in recovering the early chapters of man's history, but chiefly it denoted a new attitude to and a new interpretation of the past. Man's pre-biblical and pre-classical history has been rediscovered in the past century. We are just beginning to realize the meaning of that story. When the implications of man's tremendous achievement in lifting himself out of savagery and into civilization are fully realized, we shall have a firmer basis for building modern society. "In the splendor of that buoyant life of the human soul which has somehow come up out of the impenetrable deeps of past ages and risen so high, they shall find a glorious prophecy of the supreme future of the race."

Putting his faith in man, Breasted was thus what has been called in these skeptical 1930's "an old-fashioned liberal." He had no patience with attempts to control men by governmental decree, and he decried a centralization of government which might inhibit man's urge to lift himself. Despite his discouragement over the actual working of democratic government, he believed in it and hoped that generations of education might provide the necessary moral implementing of democracy. As

his Oriental Institute grew into a large plant maintained by the patronage of individuals or philanthropic institutions, his political-social outlook became more conservative, and he expressed alarm at possible dangers to the established social order. To the end he retained his faith that individual man has the capacity to lift himself to higher things and that this fact is the basis of all progress.

Administrative cares prevented him from entering into society as much as he might have desired, for he was a charming companion and a skillful raconteur. His family life was delightful, marked by a warm sympathy and confidence. He wrote much on the essential buoyancy of man; in the warmness of his heart he was himself a great argument for the thesis which he advanced so vigorously.

POSITIONS AND AWARDS

University of Chicago—Assistant in Egyptology, 1894-96; Instructor in Egyptology and Semitic Languages, 1896-98; Assistant Professor, 1898-1902; Associate Professor, 1902-05; Professor of Egyptology and Oriental History, 1905-33; (Distinguished Service Professor, 1927-29; Charles H. Swift Distinguished Service Professor, 1929-30; Ernest de Witt Burton Distinguished Service Professor, 1930-33); Professor Emeritus, 1933- ; Chairman, Department of Oriental Languages and Literatures, 1915-33; Assistant Director, Haskell Oriental Museum, 1895-1901; Director, 1901-31; Director, Egyptian Expedition, 1905-07; Director, Oriental Institute, 1919- .

Editorial—Associate Editor, *American Journal of Semitic Languages and Literatures,* 1902-05; Co-operating Editor, 1906- ; Associate Editor, *American Journal of Archaeology,* 1925- ; on editorial staff, *Art and Archaeology,* 1923- .

Honorary degrees and awards—B.D., Chicago Theological Seminary, 1899; LL.D., University of California, 1918; Litt.D., Oxford, 1922; LL.D., Princeton, 1929; gold medal, Geographic Society of Chicago, 1929; Rosenberger gold medal for achievement through research of benefit to humanity, 1929; gold medal,

Holland Society of New York, 1930; Fine Arts Medal, American Institute of Architects, 1934.

Lectureships—Thomas Museum Lecturer, Richmond College, Virginia, 1898; Morse Lecturer, Union Theological Seminary, 1912; Earl Lecturer, University of California and Pacific School of Religion, 1918, 1930; William Ellery Hale Lecturer, National Academy of Sciences, 1919; Haskell Lecturer, Oberlin College, 1922; Henry Ward Beecher Lecturer, Amherst College, 1924; first Messenger Lecturer, Cornell University, 1925; first Mary Flexner Lecturer, Bryn Mawr College, 1929.

American Associations (partial)—American Association for the Advancement of Science, fellow, 1933- ; American Association of Museums, member of council, 1932-34; American Association of University Professors, member of council, 1930-31; American Council of Learned Societies, member of advisory board, 1931- ; chairman of advisory board, 1933- ; American Historical Association, president, 1928; American Institute of Persian Art and Archaeology, member of board of directors, 1930; American Oriental Society, president, 1918; American Philosophical Society, vice-president, 1927-33; American Schools of Oriental Research, trustee, 1927- ; Art Institue of Chicago, honorary curator of Egyptian antiquities; Field Museum of Natural History, honorary member, 1926- ; History of Science Society, president, 1926; Laboratory of Anthropology, Inc., trustee, 1932- ; League of Nations Association, Inc., member of advisory council, 1930- ; National Academy of Sciences; National Research Council; New Orient Society of America, honorary president, 1932-33; Pan American Union, member of co-operating committee of the United States, 1932; Princeton University, member of visiting committee for the Department of Art and Archaeology, 1932- ; Renaissance Society of University of Chicago, member of board of directors, 1930-31, 1933; Southwest Museum, member of advisory council, 1927- ; World Fellowship of Faiths, member of national committee, 1933- .

Foreign Associations—Collaborator on Egyptian Dictionary, Berlin, 1899-1900; on mission to museums of Europe for Egyp-

tian Dictionary, by commission of Royal Academies of Germany, 1900-01; Second International Archaeological Congress, Cairo, Egypt, United States delegate, 1909; Seventeenth and Nineteenth International Congresses of Orientalists, Oxford, England, 1928, and Rome, Italy, 1935, United States delegate; Eighteenth International Congress of Orientalists, Leyden, Holland, chairman of United States delegation, 1931; Académie Royale des Sciences, des Lettres et des Beaux Arts de Belgique, corresponding fellow; British Academy, corresponding fellow; Preussische Akademie der Wissenschaften, corresponding member; Bayerische Akademie der Wissenschaften, corresponding member; Academia de la Historia (Spain), corresponding member; Académie des Inscriptions et Belles Lettres (Institut de France), foreign member; Kongelige Danske Videnskabernes Selskab, foreign member; Society of Antiquaries (London), honorary member; Association pour l'Etude de l'Histoire Turque, honorary member; Royal Asiatic Society, honorary member; Archaeologisches Institut des Deutschen Reichs, honorary foreign member.

JAMES HENRY BREASTED

BIBLIOGRAPHY

Articles and reviews having a minor or temporary interest have been omitted from this bibliography.

1891

The order of the sentence in the Hebrew portions of Daniel. *Hebraica,* VII, pp. 245-252.

1893

The development of the priesthood in Israel and Egypt; a comparison. *Biblical World,* new series, II, pp. 19-28.

1894

De hymnis in solem sub rege Amenophide IV conceptis. Ph.D. dissertation, University of Berlin. Berlin. 62 pp.

Erman, Adolf, Egyptian Grammar; a translation from the German of Erman's Aegyptische Grammatik. London. viii, 201, 70 pp.

1896

A sketch of Egyptian history with special reference to Palestine down to about 950 B.C. *Biblical World,* new series, VII, pp. 438-458.

1897

The Israel tablet. *Biblical World,* new series, IX, pp. 62-68.

A sketch of Egyptian history from the fall of the native kings to the Persian conquest. *Biblical World,* new series, IX, pp. 415-428.

The latest accessions to Haskell Oriental Museum. *Biblical World,* new series, X, pp. 483-491.

Review of G. C. C. Maspero, "The struggle of the nations." *Dial,* XXII, pp. 282-284.

Review of W. M. F. Petrie, "History of Egypt during the XVIIth and XVIIIth dynasties." *American Historical Review,* II, pp. 324-327.

1899

The length and season of Thutmose III's first campaign. *Zeitschrift für ägyptische Sprache und Altertumskunde,* XXXVII, pp. 123-129.

Ramses II and the princes in the Karnak reliefs of Seti I. *Zeitschrift für ägyptische Sprache und Altertumskunde,* XXXVII, pp. 130-139.

1900

A new chapter in the life of Thutmose III. *Untersuchungen zur Geschichte und Altertumskunde Aegyptens,* II, 2. Leipzig. 31 pp.

King Harmhab and his Sakkara tomb. *Zeitschrift für ögyptische Sproche und Altertumskunde,* XXXVIII, pp. 47-50.

The monuments in the inscriptions. *Proceedings, Society of Biblical Archoealogy,* XXII, pp. 88-95.

The annals of Thutmose III and the location of Megiddo. *Proceedings, Society of Biblical Archaealogy,* XXII, pp. 96-98.

1901

The philosophy of a Memphite priest. *Zeitschrift für ägyptische Sprache und Altcrtumskunde,* XXXIX, pp. 39-54, and *Open Court,* XVII (1903), pp. 458-479.

The obelisks of Thutmose III and his building season in Egypt. *Zeitschrift für ägyptische Sproche und Altertumskunde,* XXXIX, pp. 55-61.

Die Eigennamen auf dem Vatikanskarabäus Amenhoteps III. *Zeitschrift für ögyptische Sprache und Altertumskunde,* XXXIX, pp. 65-66.

Zur *Ḥb-sd*-Frage. *Zeitschrift für ögyptische Sproche und Altertumskunde,* XXXIX, p. 85.

Die königlichen Totenopfer. *Zeitschrift für ägyptische Sproche und Altertumskunde,* XXXIX, p. 85.

The Wadi Halfa stela of Senwosret I (Usertsen I). *Proceedings, Society of Biblical Archoeology,* XXIII, pp. 230-235.

Varia. *Praceedings, Socicty af Biblicol Archoeology,* XXIII, pp. 236-243.

1902

A city of Ikhenaton in Nubia. *Zeitschrift für ögyptische Sprache und Altertumskundc,* XL, pp. 106-113.

The mythological text from Memphis again. *Proceedings, Society af Biblical Archoeolagy,* XXIV, p. 300.

The transliteration of Egyptian. *Proceedings, Society of Biblical Archoeology,* XXIV, pp. 359-361.

The first philosopher. *Monist,* XII, pp. 321-336.

1903

The battle of Kadesh. *University of Chicogo Decennial Publicotians,* first series, V, pp. 81-126.

1903-04

Review of E. A. T. W. Budge, "History of Egypt." *American Historicol Review,* IX, pp. 120-126.

1904

The eleventh dynasty of Egypt. In Eduard Meyer's "Aegyptische Chronologie" (Berlin, 1904), pp. 156-161, and *American Jaurnol of Semitic Longuages ond Literotures,* XXI (1905), pp. 110-114.

The earliest occurrence of the name of Abram. *Americon Jaurnal af Semitic Languoges ond Literatures,* XXI, pp. 22-36.

1905

Egypt through the stereoscope. New York, Underwood and Underwood, 351 pp. and 100 stereographs. (Later edition, 1908.)

A history of Egypt; from the earliest times to the Persian conquest. New York, Scribner. xxx, 634 pp. (other editions, 1909, 1912, 1924. German edition, 1910. Braille edition, 1910. Russian edition, 1915. French edition, 1926. Arabic edition, 1929.)

A new light on the history of the eleventh dynasty. *American Journal of Semitic Languages and Literatures,* XXI, pp. 163-166.

The report of Wenamon. *American Journal of Semitic Languages and Literatures,* XXI, pp. 100-109.

When did the Hittites enter Palestine? *American Journal of Semitic Languages and Literatures,* XXI, pp. 153-158.

Review of W. Spiegelberg, "Aegyptologische Randglossen zum Alten Testament." *American Journal of Semitic Languages and Literatures,* XXI, pp. 247-250.

1906

The oldest fixed date in history. *Biblical World,* new series, XXVIII, pp. 108-112.

The temples of Lower Nubia. Oriental Exploration Fund of the University of Chicago; report of the work of the Egyptian Expedition, season of 1905-06. Chicago. 64 pp. Reprinted from *American Journal of Semitic Languages and Literatures,* XXIII, pp. 1-64.

1906-07

Ancient records of Egypt. Chicago, University of Chicago Press. 5 volumes.

1908

A history of the ancient Egyptians. New York, Scribner. ix, 469 pp. (Another edition, 1913.)

The monuments of Sudanese Nubia. Oriental Exploration Fund of the University of Chicago: report of the work of the Egyptian Expedition, season of 1906-07. Chicago. 110 pp. Reprinted from *American Journal of Semitic Languages and Literatures,* XXV, pp. 1-110.

Recovery and decipherment of the monuments of ancient Ethiopia. *Biblical World,* new series, XXXII, pp. 376-385.

Discovery of the temple of the heretic king. *Independent,* LXIV, pp. 135-140.

1909

The royal feud in the Wadi Halfa temple. *Proceedings, Society of Biblical Archaeology,* XXXI, pp. 269-279.

1909-10

A reading journey through Egypt. *Chautauquan,* articles in volumes LVI-LVIII.

1910

The royal feud in the Wadi Halfa temple: a rejoinder. *American Journal of Semitic Languages and Literatures,* XXVI, pp. 162-168.

1911

The "Field of Abram" in the geographical list of Sheshonk I. *Journal, American Oriental Society,* XXXI, pp. 290-295.

1912

Development of religion and thought in ancient Egypt; lectures delivered under the Morse Foundation at Union Theological Seminary. New York, Scribner. xix, 379 pp.

1913-14

Reviews of H. R. H. Hall, "Ancient history of the near east." *American Historical Review,* XIX, pp. 582-586, and *American Journal of Semitic Languages and Literatures,* XXX, pp. 125-137 (with remarks on Western Asia by D. D. Luckenbill).

1914

Outlines of European history. Joint author with James Harvey Robinson. Boston, Ginn. 2 volumes. (Part I of this was issued as "A short ancient history" in 1915.)

The eastern Mediterranean and early civilization in Europe. *American Historical Association, Annual Report for 1914,* I, pp. 103-112.

1916

Ancient times; a history of the early world. Boston, Ginn. 742 pp. (2nd edition, 1935. Swedish edition, 1925. Braille edition, 1925. Arabic edition, 1926. "A brief history of ancient times" by Hughes-Jones is an abridged edition, London, 1927.)

The Breasted ancient history series. Joint author with Carl F. Huth. Chicago, Denoyer-Geppert. 16 maps. (Similarly "Ancient-medieval-modern history maps," 1918; "Ancient history atlas," 1918; new edition, 1920; "Teacher's manual accompanying the Breasted-Huth ancient history maps," 1918.)

The physical processes of writing in the early Orient and their relation to the origin of the alphabet. *American Journal of Semitic Languages and Literatures,* XXXII, pp. 230-249.

Studio of an Egyptian portrait sculptor in the fourteenth century B. C. *Art and Archaeology,* IV, pp. 232-242.

1917

The earliest boats on the Nile. *Journal of Egyptian Archaeology*, IV, pp. 174-176.

1919

Survey of the ancient world. Boston, Ginn. xi, 417 pp. (Japanese edition, 1933.)

The earliest internationalism. *University of California; Semicentenary Celebration of the Founding of the University of California . . . (1868-1918)*, pp. 192-214.

The place of the Near Orient in the career of man and the task of the American orientalist. *Journal, American Oriental Society*, XXXIX, pp. 159-184.

1919-20

The origins of civilization. *Scientific Monthly*, IX, pp. 289-316, 416-432, 561-577; X, pp. 86-105, 182-209, 249-268.

1920

The first expedition of the Oriental Institute of the University of Chicago. *Journal, American Oriental Society*, XL, pp. 282-285.

History of Europe, ancient and medieval. Joint author with J. H. Robinson. Boston, Ginn. xiii, 665, xiv pp. (Revised edition, 1929.)

The new past. *University of Chicago; the University Record*, new series, VI, pp. 237-256.

1921

General history of Europe. Joint author with J. H. Robinson and Emma Peters Smith. Boston, Ginn. xiv, 667, xxxviii pp.

The University of Chicago expedition to the Near East (1919-1920). *University of Chicago; the University Record*, new series, VII, pp. 6-25.

1921-22

Reviews of C. Autran, "Phéniciens." *Classical Philology*, XVI, pp. 289-296, and *American Journal of Semitic Languages and Literatures*, XXXVIII, pp. 142-149.

1922

The Oriental Institute of the University of Chicago; a beginning and a program. *Oriental Institute Communications*, I. Chicago. 96 pp.

The Edwin Smith papyrus; an Egyptian medical treatise of the seventeenth century before Christ. *New York Historical Society Quarterly Bulletin*, VI, pp. 3-31, and *Bulletin, Society of Medical History of Chicago*, III, pp. 58-78.

The Edwin Smith papyrus; some preliminary observations. *Recueil d'études égyptologiques dédiées à la mémoire de Jean-François Champollion,* pp. 385-429.

Peintures d'époque romaine dans le désert de Syrie. *Syria, revue d'art oriental et d'archéologie,* III, pp. 177-206.

1924

Oriental forerunners of Byzantine painting. *Oriental Institute Publications,* I. Chicago. 105 pp.

Our world today and yesterday. In collaboration with J. H. Robinson and Emma P. Smith. Boston, Ginn. xiv, 625, xlix pp.

Cambridge ancient history. Vol. II, chapters III-VIII, pp. 40-195.

Historical tradition and Oriental research. *Proceedings, National Academy of Sciences,* X, pp. 289-294, and *Smithsonian Institution; Annual Report of the Board of Regents, 1924,* pp. 409-414.

Some experiences in the tomb of Tutenkhamon. *University of Chicago; the University Record,* new series, X, pp. 29-42, and *Art and Archaeology,* XVII, pp. 3-18; and *University of Chicago; Alumni Council; Alumni Pamphlets,* no. 2.

Man's early history in the light of recent revolutionary discoveries. *These Eventful Years; the Twentieth Century in the Making,* II, Chapter 70, pp. 475-492.

1925

The new past. *The new past and other essays on the development of civilization,* edited by E. H. Carter (Oxford, 1925), pp. 1-28.

Review of C. R. Williams, "Gold and silver jewelry and related objects" (New York Historical Society). *American Journal of Semitic Languages and Literatures.* XLI, pp. 200-202.

1926

The conquest of civilization. New York, Harper, xxiv, 717 pp. (Spanish edition, 1934. Revised edition, 1937.)

Luxor and Armageddon; the expansion of the Oriental Institute of the University of Chicago. *Art and Archaeology,* XXII, pp. 154-166.

1928

A laboratory for the investigation of early man. *Scribner's Magazine,* Nov. 1928, LXXXIV, pp. 516-529.

1929

The new crusade. *American Historical Review,* XXXIV, no. 2, pp. 215-236.

1930

The Edwin Smith surgical papyrus. *Oriental Institute Publications,* III-IV. Chicago. 2 volumes.

The predynastic union of Egypt. *Bulletin de l'Institut Français d'Archéologie Orientale,* XXX, pp. 709-724.

1932

Assyrian relief sculpture and the influence of Egyptian art. *Studies presented to F. L. Griffith* (Egypt Exploration Society, London), pp. 267-271.

The rise of man and modern research. *Smithsonian Institution; Annual Report,* 1932, pp. 411-428.

1933

The dawn of conscience. New York, Scribner, xxvi, 431 pp.

The Oriental Institute. *University of Chicago Survey,* XII. Chicago, xxiii, 455 pp.

John Merlin Powis Smith. *American Journal of Semitic Languages and Literatures,* XLIX, pp. 73-79.

Archaeology. *Compton's Pictured Encyclopedia,* Chicago, I, pp. 249-254.

1935

Unearthed at Persepolis. *Architecture,* LXXII, pp. 249-254.

The Ras Shamra statue of Sesostris-Onekh. *Syria; revue d'art oriental et d'archéologie,* XVI, pp. 318-320.

History and social idealism. *Rationalist Annual for the Year 1936,* pp. 55-66.

The beginnings of time-measurement and the origins of our calendar. *Scientific Monthly,* XLI, pp. 289-304.

1936

The history of our civilization. Joint author with James Harvey Robinson and Charles A. Beard. Boston, Ginn. 2 volumes. (In press.)

Lafayette B. Mendel

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OF

LAFAYETTE BENEDICT MENDEL

1872–1935

BY

RUSSELL H. CHITTENDEN

PRESENTED TO THE ACADEMY AT THE AUTUMN MEETING, 1936

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To write a biographical sketch of a man in such a way as to make clear what manner of man he was, what the character and extent of his accomplishments, and his degree of usefulness in the scientific world, is a somewhat difficult task especially when the one who essays such a task has been his close associate for forty years or more, and where there is a certain fixed limit to the number of words to be used. Where such a degree of brevity is called for, there must of necessity be careful selection with exercise of good judgment, while the many years of intimate relationship, though affording clear insight into character and activities, may lead to a somewhat biased impression. However this may be, the following sketch will, I trust, give a fair picture of the man and his work.

Lafayette Benedict Mendel was born in Delhi, New York, on February 5, 1872, his parents having come to this country from Württemberg, Germany. The father, Benedict Mendel, was born in Aufhausen, March 4, 1833, and came to the United States in 1851, settling eventually in Delhi where he was a merchant from 1862 to his death in 1907. The mother, Pauline Ullman, was born in Eschenau, February 22, 1844, and came to this country in 1870, being married to Benedict Mendel that same year. Of this marriage there were two children, Lafayette and a younger brother who was frail and who died in 1901.

To Lafayette there must have been transmitted all the mental power and strength of character possessed by the parents, for he was unusually precocious, developing very early a fondness for study and an ability to assimilate knowledge which led to rapid progress, so much so that he presented himself at New Haven for the Yale preliminary examinations in Latin, Greek, and mathematics at the early age of fourteen. His training was at Delhi in the local school, the Delaware Academy, where he completed his preparatory studies and took the final examinations

for Yale College in June, 1887. Prior to entering Yale, he went to Albany for a competitive examination through which he hoped to win a state scholarship. In this he was successful, gaining not only a scholarship but confidence in his ability to compete with others older than himself.

Throughout his undergraduate course in Yale College he maintained a fine record for scholarship, graduating with the degree of B.A. in 1891, the youngest man in his class, nineteen years and five months, his senior appointment being a Philosophical Oration, with Phi Beta Kappa standing. During his undergraduate course his studies were largely the classics, economics, and the humanities in general, with only a limited attention to the sciences.

Although the baby of the class, he nevertheless gained wide recognition from his classmates not only for his intellectual keenness, but also because of his winning personality coupled with a measure of good sense and with broad interests tokening a maturity of mind far beyond what would be expected in a youth of his years. In this undergraduate period he showed many of those characteristics which contributed so largely to the success of his scientific career. Not easily swayed by the currents of the moment he was prone to think things through and form his own judgment quite independent of the prevailing sentiment. This habit of thoughtful consideration of all sides of a problem was a striking indication of his mental independence and led many of his classmates to prophesy that young Mendel would go far, a feeling more than justified by later events. As one of his classmates wrote of him in later years, "Destined from the first to be a scholar, as rare then as now, he had his goal, and those who knew him well realized that he would never let anything stand in the way of attainment. Always friendly, he had little time for general conversation. He rigidly adhered to a simple mode of life to avoid distractions. Self-denying, he acquired self-control. Idealistic by nature, he developed spiritual values while devoting his entire life to a search for truth. Tolerant, without prejudice, untrammeled by the ideas of others, he approached his problems with originality and an open mind."

Having completed his undergraduate course and with a grad-

uate fellowship awarded for his successful accomplishments, he returned to Yale in the fall of 1891 and entered the Sheffield Scientific School to take up the study of physiological chemistry with the writer. He had had some physics and chemistry and so was prepared in a way for the work that lay before him, but he was lacking experience in experimental work and found difficulty at first in grasping the full significance of the experiments he was called upon to perform and the proper interpretation of the results obtained. Trained as he was in the study of the printed page with general acceptance of the statements presented, it was not easy to adapt himself to a laboratory procedure where he must collect the facts for himself and then reason out their significance. Difficulties of this character, however, were soon overcome and he made such rapid progress in his studies, with a thesis that had sufficient merit to be given a place in the English *Journal of Physiology,* that he was awarded the Ph.D. degree in 1893. The following year he became my assistant in the Sheffield Laboratory of Physiological Chemistry, followed soon by his appointment as instructor, thus beginning his long term of service as a teacher in the subject to which he had decided to devote his life. During the college year, 1895-96, he was granted leave of absence, the time being spent at the University of Breslau with R. Heidenhain and at the University of Freiburg with E. Bauman in research work with these two eminent physiologists. In 1897 he was given the rank of assistant professor in the Sheffield Scientific School and in 1903 he was advanced to the position of professor of physiological chemistry with membership in the Governing Board of the Sheffield Scientific School.

This somewhat rapid advancement was fully justified by his accomplishments, both as a teacher dealing with undergraduate and post-graduate students, and by his activity in the field of chemico-physiological research. During all this period, indeed up to the writer's retirement from active service in 1922, Mendel took an increasing share in the responsibilities of the steadily growing Department of Physiological Chemistry in the Sheffield Scientific School and after the above date he became the head of the department. In 1921 with the changes incidental to the reorganization of the University, he was appointed Sterling

Professor of Physiological Chemistry in the University, with membership in the faculties of the Graduate School and the School of Medicine, as well as the Sheffield Scientific School, thus binding the Department of Physiological Chemistry more closely to all schools of the University where this branch of science could be of service. His responsibilities were thereby broadened, but he met all the requirements of the new position with increasing success, as testified by the growth in numbers of graduate students coming from other universities throughout the country and indeed from foreign countries, as well as by the greatly increased activity in research.

Dr. Mendel was a born teacher, strengthened by years of hard study and profound thinking. He loved teaching and this phase of his life work he pursued with a wholehearted enthusiasm which he communicated to his students, arousing in them a deep interest in their work. He was gifted with the power of presenting even the more difficult subjects with which he had to deal in a most lucid manner and in language both forceful and readily understandable. But beyond all this he was endowed with qualities that aroused the interest and devotion of his students. As one of his former pupils, now professor of physiological chemistry in a mid-western university, wrote shortly after Mendel's death, "To his students Professor Mendel was more than a distinguished scientist and a great teacher. Somehow, he directed the aspirations and broadened the perspective of those who came under the charm of his personality. He was not content merely to impart facts to, or to perfect the scientific technic of those about him. These things he did, but in addition he implanted ideals—ideals of tolerance, unselfishness, intellectual loyalty and service. . . . His students saw him as the personification of the ideals which they admired. They caught his spirit; and determined, perhaps unconsciously, to 'carry on' in his way. Because of these attributes so difficult to describe and yet none the less real, Mendel won and retained the confidence, the respect, and the devotion of his pupils. He became their guide and counselor." The many students trained under his inspiring guidance now holding university positions of importance in the field

of physiological chemistry throughout the country constitute a living testimonial of his wise leadership.

With such a personality added to his broad knowledge and sound judgment, Mendel, approachable, gracious, magnetic, was quite naturally called on during his years of active service to give aid in many projects of a scientific nature. Thus, he served on the Board of Directors of the Russell Sage Institute for Pathology; he was long a member of the Council on Pharmacy and Chemistry of the American Medical Association; he was the first president of the American Institute of Nutrition; successively treasurer, vice-president, and president of the American Society of Biological Chemists; member of the Educational Advisory Board of the John Simon Guggenheim Medical Foundation; councillor of the American Home Economics Association; one of the Commission on Medical Education; a member of one of the sub-committees of the White House Conference on Child Welfare and Development; research associate of the Carnegie Institution of Washington and of the Connecticut Agricultural Experiment Station; official advisor on scientific research to the Protein and Nutrition Division, Bureau of Chemistry and Soils, United States Department of Agriculture; and at the close of the late war he was abroad for a time as a member of the *Commission Scientifique Interalliée du Ravitaillement.* For many years he served as a member of the Editorial Board of the *Journal of Biological Chemistry,* as one of the editors of the Scientific Monograph Series of the American Chemical Society and as a member of the Editorial Board of the *Journal of Nutrition.* In these and many other connections Dr. Mendel gave freely of his time and thought for the advancement of sound knowledge along the lines of his chosen field of work.

But Dr. Mendel's position in the world of science rests mainly upon his accomplishments in research, especially in the field of nutrition, where he made for himself and for the laboratory which he represented a broadly recognized reputation. Examination of the attached bibliography reveals a degree of research activity during the forty years from 1894 to 1934 that is highly impressive. Plainly, there was never an idle moment, but all his energies were directed to the study of a variety of

problems, solution of which might throw light on many questions of primary importance. The bibliography is also suggestive of the personal magnetism of the man who could draw and hold so many research workers, ready and anxious to cooperate with him.

In the early period of Mendel's research activity his efforts were directed largely to the chemical aspects of digestion, absorption and secretion with some studies of nitrogenous metabolism and the paths of excretion, especially of certain inorganic compounds. His early work on digestion led to critical study of enzyme reactions, particularly in connection with the digestion of animal and vegetable proteins, using both animal and vegetable enzymes. The proteolysis of a crystalline vegetable protein, edestin, was studied for the first time by him in connection with the writer. These studies led in turn to a chemico-physiological study of various derivatives of the proteins, in which the physiological action of the primary products of digestion was given careful attention. This was at a time when knowledge of the digestive processes involved in the utilization of protein foods was very incomplete and unsatisfactory. Peptones and the several proteoses as normal products of digestion were being given undue prominence in view of later knowledge regarding their ultimate breaking down into the various amino acids. Study of the physiological action of the proteoses gave clear indication that they could not be absorbed as such into the blood since they were so obviously inimical to health. Plainly the ultimate products of protein digestion must be given more thoughtful consideration and attention was being focused more and more on the amino acids present in the protein molecules.

In the space at our disposal it is impossible to consider in detail the many more or less related lines of research carried on by Mendel and his coworkers; all bearing in greater or less degree on the broad subject of nutrition. There are, however, two lines of work deserving of special consideration since they extended over many years and brought results of the highest value in helping to create a new science of nutrition. One line of work had to do with the relationship between the chemical constitution of a great variety of food substances, especially the proteins of

vegetable and animal origin, and their physiological or food value, while the other line of work had to do with the accessory factors essential for the normal growth of the young and of the normal health of the adult.

In the meantime Mendel had entered on a lengthy series of chemical studies on growth, in cooperation with a number of co-workers in the laboratory, but in 1911 there appeared a suggestive paper, with Thomas B. Osborne, "on the rôle of different proteins in nutrition and growth." This ushered in a period of cooperative work covering nearly twenty years up to the death of Dr. Osborne in 1929. Dr. Osborne, long connected with the nearby Connecticut Agricultural Experiment Station, had been occupied for many years with a study of proteins, especially those of vegetable origin, devoting much time to the isolation of the pure proteins and to a study of their chemical constitution. He found many striking differences in their content of the various amino acids of which they are composed, differences both qualitative and quantitative. Plainly such differences in chemical make-up might reasonably be expected to have some influence on nutritive values. Some of the amino acids might prove to be essential, others non-essential, to the growth and maintenance of the body. Osborne was primarily a chemist; Mendel versed more fully in the physiological aspects of nutrition and growth; the two making a combination of forces that might accomplish much. In the words of another "the ways of two explorers who started at different points met in a common interest and thus Osborne and Mendel joined hands in the common objective of the study of the problems of nutrition based on the appraisal of the food values of pure chemical substances of various degrees of complexity."

Aided by grants from the Carnegie Institution of Washington, Osborne and Mendel began their classical studies on nutrition with albino rats as subjects. This necessitated first a long series of observations on such animals in captivity, how best to maintain them in good physiological condition with the kinds of food adapted to normal nutrition, using relatively simple diets. They were then ready to begin their experiments proper with purified food products, having in mind especially the relative values of

various isolated proteins for the maintenance in normal condition of adult animals and for the proper growth of young animals. In this connection it is to be remembered that, as Osborne found, purified proteins from various sources may differ greatly in their content of the individual amino acids. Thus, for example, of three proteins in the wheat kernel, leucosin contains 6.73 per cent of glutamic acid, while gliadin and glutenin contain respectively 37.33 and 23.42 per cent of this amino acid. Further, leucosin contains 2.83 per cent of histidine, while gliadin contains only 0.58 per cent of this amino acid. Again, leucosin yields 2.75 per cent of lysine, while none of this amino acid is present in gliadin. With such wide differences in chemical structure it would be strange indeed if these three proteins did not have different physiological values.

Recent years had brought new ideas regarding the relation of the food proteins to tissue proteins. With increasing evidence of marked structural differences between the albuminous compounds of different origin, it had become clear that it is impossible to develop noticeable changes in the character of the tissues of animals correlated with the character of the food consumed. In other words, tissue cells and fluids remain characteristic and specific for a species, whatever the chemical make-up of the food ingested. As Osborne and Mendel pointed out, the structural peculiarities which determine the individuality of the proteins are lost by the digestive processes and it is with the amino acids, the final products of the breaking down of proteins that we have to deal in considering the construction or renewal of the specific body proteins. This chemical fixity of the tissues under widely differing nutrient conditions pointed clearly to the supposition that the animal must construct its tissue proteins, by a process of synthesis, from the amino acid fragments furnished by protein hydrolysis. Again, it was a question whether all the amino acids formed by protein hydrolysis are equally indispensable. There was some evidence that the cyclic compounds, such as tyrosine, tryptophane, histidine, and phenylalanine were absolutely necessary for the welfare of the organism while other evidence pointed to the possibility of the synthesis of some amino acids *de novo* in the animal organism.

With such and other related ideas, Osborne and Mendel, keeping clearly in mind that the "processes of replacing nitrogen degraded in cellular metabolism are not of the same character as the processes of growth," or, in other words, that maintenance, repair and growth in the animal organism may be quite different processes, began their experimental work covering this long period of time.

Taking gliadin as one illustration, they found that *grown* rats having gliadin as the sole nitrogenous intake, though this protein lacked glycocoll and lysine, thrived without any evidence of alteration in well being, thus pointing to the conclusion that so far as maintenance is concerned, the protein of the food can differ widely in its amino acid make-up from the tissue proteins of the animal without affecting the well being of the latter. With *growing* rats, however, the story was quite different. Thus, young rats fed on the gliadin of wheat failed to grow, though in other respects they were quite normal. The same results were obtained with gliadin from rye, with the hordein of barley, and with zein of maize. Plainly growth required the presence in the food of certain amino acids not supplied by these incomplete proteins. This view was strengthened by the fact that the introduction of a little tryptophane and lysine with the gliadin or zein caused growth to show itself at once.

Thus, as early as 1912 Osborne and Mendel demonstrated by their many and varied maintenance experiments that "it is possible to maintain rats for periods equal to practically their entire adult lives on foods containing a single purified protein, and also that the successful food proteins may differ very widely in their chemical make-up without affecting the physical well being of the animal to any noticeable extent." In this connection it is to be observed that one rat was maintained in good condition, though without growth, for more than 530 days of adult life on a mixture of isolated food substances containing a single protein and this lacking both lysine and glycocoll; without doubt the longest experiment on record of artificial nutrition, bearing in mind that two years or thereabouts represent the rat's span of life. By experiments of such long duration the possibility of approaching certain of the problems of nutrition, many of them

very illusive in character, by "new and hitherto discredited methods of study" was clearly established. Thus, they found among other important facts that "a protein as unlike the tissue proteins as is gliadin can serve for the construction of new tissues through the intervention of the metabolic processes of the mature animal" as was illustrated with a pair of rats maintained for 178 days on gliadin as the sole protein in the diet, four healthy young being produced and reared by them. This naturally involved "not only the construction of the tissues of the young animals, but also the production of the milk by which they were successfully nourished."

The value of the painstaking experimental work of these two coworkers on the nutritive value of isolated purified proteins from many sources, especially various cereal grains, can hardly be overestimated, throwing as it does so much light on the relationship between chemical constitution and biological value; work which has had a marked influence in revolutionizing many of the earlier theories of nutrition. Further, their experiments on the relative value of different purified proteins made it quite clear that *growth* depends on nutritive conditions quite distinct from those required for maintenance. Something more than the proper proportion of essential amino acids seemed necessary if grown rats were to be kept in health and in apparent nutritive equilibrium over long periods of time.

In all their previous experiments with isolated proteins the diet contained a small amount of "protein-free milk." Many lengthy experiments finally led them to the belief that some constituent present in natural milk, distinct from "protein-free milk" is essential for prolonged maintenance. Young rats fed solely upon a natural milk food not only grew from infancy to full maturity, but also gave birth to litters of normal young which in turn thrived on diets like that furnished to their parents. Further, if rats were allowed to grow on the "protein-free milk" food until a decline in growth set in, the addition of a little milk food caused growth to again manifest itself. A second decline in growth was easily averted by further exhibition of milk food. The conclusion was obvious that the milk food contains something that is essential for *both* growth and maintenance.

In seeking for this essential accessory factor in milk, Osborne and Mendel soon found that if the lard of their simple diets was replaced by butter fat, growth and well being were maintained. In the preparation of their "protein-free milk" food, the cream component of the milk was nearly or completely removed, with ultimate decline of growth on such a diet. Repeated experiments showed them that rats which had ceased to grow and were declining on their "protein-free milk" diet at once recovered and resumed a normal rate of growth when a portion of the lard in their food was replaced by a quantity of unsalted butter. Interesting is the conclusion published in 1913: "It would seem therefore as if a substance exerting a marked influence upon growth were present in butter." They at once raised the question "what light does the experience thus far accumulated throw upon the nature of the essential substance, if there be such? Is it organic or inorganic or both?" It is thus seen that they were on the threshold of the discovery of vitamins, or more particularly of the fat-soluble vitamin A, so essential for growth and well being.

Further experiments soon demonstrated that the growth-promoting substance of milk or of butter is associated with the butter *fat* and that the power of the latter must be attributed to something which distinguishes butter from the ordinary fats, for both lard and olive oil were found to lack this growth-promoting power. In addition it seemed improbable that glycerides of any of the fatty acids ordinarily present in foods could be responsible for the promotion of growth, while lecithin and other phosphorus—or nitrogen—containing substances were excluded, since the butter fat contained neither phosphorus nor nitrogen. Cholesterol was also ruled out by the fact that lard contains even more of this substance than does butter fat. What then was the substance possessed of this extraordinary power? In studying this question, Osborne and Mendel began to consider the possibility of an unique class of substances essential for normal nutrition. Thus, they stated in one of their papers, 1913, that "The researches which have been devoted in recent years to certain diseases, notably beri-beri, have made it more than probable that there are conditions of nutrition during which certain essential, but, as yet, unknown substances must be supplied in the diet

if nutritive disaster is to be avoided. These substances apparently do not belong to the category of the ordinary nutrients, and do not fulfill their physiological mission because of the energy which they supply." As expressed by another "and as it often happens that a fundamental investigation opens new avenues not anticipated and not envisaged by the explorer, so it came about that the investigations of the food value of pure chemical substances led up to the discovery of the accessory factors essential for maintenance of the normal growth of the young and of the normal health of the adult. Such was the beginning, in this country, of the work on vitamins, work that revolutionized the existing theories of nutrition."

As their studies progressed, the horizon broadened and they soon found that adequate dietaries for growth and normal health required at least two groups of "formerly unappreciated components," i.e. fat-soluble vitamins and water-soluble vitamins. Further, growth-promoting properties were found to be associated with many and widely divergent tissues and fluids, thus implying a fairly broad distribution of these accessory substances. Thus, egg-yolk fat, wheat embryo, yeast, corn germs and glandular tissues showed "a surprising richness in growth-promoting properties aside from their protein and mineral content." Much time was devoted to investigation of the water-soluble vitamins of milk and of yeast, while thought was also given to the distribution of these particular food accessories in the various vegetable and animal tissues in general. Lack of space prevents a full discussion of the great variety of problems studied by Osborne and Mendel in their pursuit of knowledge in this particular field of nutrition. A glance at the attached bibliography, however, will give some idea of the wide scope of their investigations, while examination of the papers themselves will reveal the breadth of vision and the clarity of judgment, of these two gifted coworkers. As expressed by another in referring to their vitamin work, "contemporaneously, investigations on similar lines were initiated in other countries, but in America to Osborne and Mendel belongs the credit of the pioneer work. Indeed, to have been among the first to embark on a road which

today is traversed by explorers in many fields of biology is a testimony of great foresight and wide imagination."

Such, very briefly, is a faint outline of two chapters of Mendel's work in the field of nutrition. His mind, however, reached out in many directions, but always with a thought of the bearing of his experimental work on some aspect of nutrition. In the latter part of his life he was much interested in the relation of the chemical character of the fats used as food to the fats present in the tissues of the body.

Having a facile pen and with a broad command of the literature, he was called on to write many reviews dealing especially with nutrition and growth. Thus, in 1916, in the *Ergebnisse der Physiologie,* under the title *"Das Wachstum"* he wrote a comprehensive review of the broad subject of growth with inclusion of all the chemical data then available. The same year he published a book entitled *Changes in the Food Supply and Their Relation to Nutrition,* and in 1923 there appeared another volume, *Nutrition, the Chemistry of Life,* being the Hitchcock Lectures at the University of California for that year. In 1930 he gave the Cutler Lecture at the Harvard Medical School and at Cornell University he lectured on the Schiff Foundation. He likewise gave several of the Harvey Lectures and one of the Herter Lectures in New York dealing mainly with subjects related to nutrition.

Recognition of his broad knowledge and varied accomplishments in his chosen field of work came from many sources. In 1913 he was elected a member of the National Academy of Sciences and the same year the University of Michigan conferred on him the honorary degree of Doctor of Science. In 1927 he was awarded the gold medal of the American Institute of Chemists for his outstanding contributions to chemistry, and in 1930 Rutgers University honored him with the degree of Doctor of Science, while in 1932 Western Reserve University gave him the degree of Doctor of Laws. In 1935 the Chemists Club of New York awarded him the Conne Medal "for his outstanding chemical contributions to medicine." On his sixtieth birthday in 1932 his portrait was presented to him by professional asso-

ciates and friends and today it hangs on the wall of the seminar room in the Sterling Hall of Medicine and may serve in the years to come as a reminder to future workers in the laboratory of the man who gave of the best that was in him for the development of knowledge in the field of physiological chemistry, a teacher who represented a highly developed form of culture, which was both intellectual and personal.

During the last two years of his life Dr. Mendel suffered a painful illness which confined him to the New Haven Hospital, death coming as a relief from suffering on December 9, 1935. He was married to Alice R. Friend, a graduate of the University of Wisconsin, on July 19, 1917. A very intelligent and cultured woman, her sympathetic and helpful attitude toward his work did much to encourage him, and their life together was a very happy one. Worn out by the physical and mental strain attendant on Dr. Mendel's long illness, she died a few weeks prior to his decease. They had no children.

On April 16, 1936, memorial exercises for Dr. Mendel were held at Yale, in Strathcona Hall, when friends and associates gathered to do honor to his memory. President Angell presided and three addresses were given, by the Honorable Frederic C. Walcott, a classmate of Dr. Mendel, by Dr. Phoebus A. Levene, of the Rockefeller Institute for Medical Research, and by the writer.

In closing this brief review, I add a paragraph made use of previously: Plainly, the accomplishments of such a man as Dr. Mendel, with his broad vision, clear thinking and great industry, coupled with the important scientific data he was continually bringing to light have had, and will continue to have, a marked influence upon the growth of a more definite understanding of the science of nutrition. His love for his work, his enthusiasm over newly discovered facts, his pleasure in a successful experiment made of his labors a perpetual joy, by which his life was kept sweet and peaceful. He realized that no man can accomplish much in science except by lifting his hand and mind honestly to the tasks that lie directly in front of him, and this he did all

through life with profit to the science for which he strove and with satisfaction to his own soul. His accomplishments stand clearly revealed in the records of science and in the hearts of his fellow workers.

BIBLIOGRAPHY OF LAFAYETTE BENEDICT MENDEL

The following list of the printed writings of Dr. Mendel, based on one prepared by himself, is believed to be complete, except for writings of minor importance.

On the Proteolysis of Crystallized Globulin. (With R. H. Chittenden.) Jour. Phys., 17, 48. 1894.

The Influence of Alcohol and Alcoholic Drinks upon the Chemical Processes of Digestion. (With R. H. Chittenden.) Amer. Jour. Med. Sci., Jan'y-April, 1896. 86 pp.

On the Passage of Sodium Iodide from the Blood to the Lymph, with some Remarks on the Theory of Lymph Formation. Jour. Phys., 19, 227. 1896.

Ueber den sogenannten paralytischen Darmsaft. Pflüger's Archiv, 63, 425. 1896.

A Further Study of the Influence of Alcohol and Alcoholic Drinks upon Digestion, with Special Reference to Secretion. (With R. H. Chittenden and Holmes C. Jackson.) Amer. Jour. Phys., 1, 164-209. 1898.

The Chemical Composition and Nutritive Value of some Edible American Fungi. Amer. Jour. Phys., 1, 225-238. 1898.

Papain-Proteolysis, with some Observations on the Physiological Action of the Products formed. (With R. H. Chittenden and H. E. McDermott.) Amer. Jour. Phys., 1, 255-276. 1898.

On the Excretion of Kynurenic Acid. (With Holmes C. Jackson.) Amer. Jour. Phys., 2, 1-28. 1898.

On the Paths of Absorpton for Proteids. Amer. Jour. Phys., 2, 137-141. 1899.

A Chemico-Physiological Study of Certain Derivatives of the Proteids. (With R. H. Chittenden and Yandell Henderson.) Amer. Jour. Phys., 2, 142-181. 1899.

On Absorption from the Peritoneal Cavity. Amer. Jour. Phys., 2, 342-351. 1899.

Observations on the Nitrogenous Metabolism of the Cat, especially on the Excretion of Uric Acid and Allantoin. (With Ernest W. Brown.) Amer. Jour. Phys., 3, 261-270. 1900.

On the Occurrence of Iodine in the Thymus and Thyroid Glands. Amer. Jour. Phys., 3, 285-290. 1900.

On Uric Acid Formation after Splenectomy. (With Holmes C. Jackson.) Amer. Jour. Phys., 4, 163-169. 1900.

Brief Contributions to Physiological Chemistry. Amer. Jour. Phys., 4, 243-263. 1900.

On the Excretion of Kynurenic Acid. (With Edward C. Schneider.) Amer. Jour. Phys., 5, 427. 1901.

Some Decomposition Products of the Crystallized Vegetable Proteid Edestin. (With P. A. Levene.) Amer. Jour. Phys., 6, 48. 1901.

Observations on the Digestion of Proteids with Papain. (With Frank P. Underhill.) Trans. Conn. Acad. Arts and Sci., 11, 1. 1901.
Observations on a Case of Cyclic Albuminuria. (With Donald R. Hooker.) Jour. Exper. Med., 5, 647. 1901.
On the Lymphagogic Action of the Strawberry, and Post-Mortem Lymph Flow. (With Donald R. Hooker.) Amer. Jour. Phys., 7, 380. 1902.
Experimental Observations on Pancreatic Digestion and the Spleen. (With Leo F. Rettger.) Amer. Jour. Phys., 7, 387. 1902.
Observations on Vegetable Proteolytic Enzymes, with Special Reference to Papain. Amer. Jour. Med. Sci., August, 1902.
A Physiological Study of Nucleic Acid. (With Frank P. Underhill and Benjamin White.) Amer. Jour. Phys., 8, 377. 1903.
The Paths of Excretion for Inorganic Compounds. I. The Excretion of Strontium. (With Henry Clarke Thacher.) Amer. Jour. Phys., 11, 5. 1904.
Ueber das Vorkommen von Taurin in den Muskeln von Weichtieren. Hofmeister's Beiträge zur chemischen Physiologie und Pathologie, 5, 582. 1904.
On the Intermediary Metabolism of the Purin Bodies: The Production of Allantoin in the Animal Body. (With Benjamin White.) Amer. Jour. Phys., 12, 85. 1904.
On the Absorption and Utilization of Proteids without Intervention of the Alimentary Digestive Processes. (With Elbert W. Rockwood.) Amer. Jour. Phys., 12, 336. 1904.
Experimental Studies on the Physiology of the Molluscs.—First Paper. (With Harold C. Bradley.) Amer. Jour. Phys., 13, 17. 1905.
Experimental Studies on the Physiology of the Molluscs.—Second Paper. (With Harold C. Bradley.) Amer. Jour. Phys., 14, 313. 1905.
On the Utilization of Various Carbohydrates without Intervention of the Alimentary Digestive Processes. (With Philip H. Mitchell.) Amer. Jour. Phys., 14, 239. 1905.
On the Paths of Absorption from the Liver. (With Frank P. Underhill.) Amer. Jour. Phys., 14, 252. 1905.
A Study of the Proteins of the Castor Bean, with Special Reference to the Isolation of Ricin. (With Thomas B. Osborne and Isaac F. Harris.) Amer. Jour. Phys., 14, 259. 1905.
The Paths of Excretion for Inorganic Compounds.—II. The Excretion of Barium. (With Dudley F. Sicher.) Amer. Jour. Phys., 16, 147. 1906.
The Paths of Excretion for Inorganic Compounds.—III. The Excretion of Rubidium. (With Oliver E. Closson.) Amer. Jour. Phys., 16, 152. 1906.
Experiments on the Physiological Action and Metabolism of Anhydro-oxymethylene-diphosphoric Acid (Phytin Acid). (With Frank P. Underhill.) Amer. Jour. Phys., 17, 75. 1906.

Experimental Studies on the Physiology of the Molluscs.—Third Paper. (With Harold C. Bradley.) Amer. Jour. Phys., 17, 143. 1906.

Childhood and Growth. F. A. Stokes Co. New York. 1906.

On Absorption from the Peritoneal Cavity. (With H. Gideon Wells.) Amer. Jour. Phys., 18, 150. 1907.

Nutrition. (With R. H. Chittenden.) Osler's Modern Medicine, 1, 639. 1907.

Observations on Nitrogenous Metabolism in Man after Removal of the Spleen. (With Robert Banks Gibson.) Amer. Jour. Phys., 18, 201. 1907.

Is the Saliva of the Dog Amylolytically Active? (With Frank P. Underhill.) Jour. Biol. Chem., 3, 135. 1907.

The Rate of Elimination of Uric Acid in Man. (With Ernest W. Brown.) Jour. Amer. Med. Assn., 49, 869. 1907.

Chemical Studies on Growth.—I. The Inverting Enzymes of the Alimentary Tract, especially in the Embryo. (With Philip H. Mitchell.) Amer. Jour. Phys., 20, 81. 1907.

Chemical Studies on Growth.—II. The Enzymes Involved in Purine Metabolism in the Embryo. (With Philip H. Mitchell.) Amer. Jour. Phys., 20, 97. 1907.

Chemical Studies on Growth.—III. The Occurrence of Glycogen in the Embryo Pig. (With Charles S. Leavenworth.) Amer. Jour. Phys., 20, 117. 1907.

Chemical Studies on Growth.—IV. The Transformation of Glycogen by the Enzymes of Embryonic Tissues. (With Tadasu Saiki.) Amer. Jour. Phys., 21, 64. 1908.

Chemical Studies on Growth.—V. The Autolysis of Embryonic Tissues. (With Charles S. Leavenworth.) Amer. Jour. Phys., 21, 69. 1908.

Chemical Studies on Growth.—VI. Changes in the Purine-, Pentose-, and Cholesterol-Content of the Developing Egg. (With Charles S. Leavenworth.) Amer. Jour. Phys., 21, 77. 1908.

Chemical Studies on Growth.—VII. The Catalase of Animal Embryonic Tissues. (With Charles S. Leavenworth.) Amer. Jour. Phys., 21, 85. 1908.

Chemical Studies on Growth.—VIII. The Occurrence of Lipase in Animal Embryonic Tissues. (With Charles S. Leavenworth.) Amer. Jour. Phys., 21, 95. 1908.

Chemical Studies on Growth.—IX. Notes on the Composition of Embryonic Muscular and Nervous Tissues. (With Charles S. Leavenworth.) Amer. Jour. Phys., 21, 99. 1908.

Das Verhalten einiger unverdaulicher Kohlehydrate im Verdauungstrakt. Zentralblatt für die gesamte Physiologie und Pathologie des Stoffwechsels, 2, 641. 1908.

Der Einfluss der Nahrung auf die chemische Zusammensetzung des Tierkörpers. Biochemische Zeitschrift, 11, 281. 1908.

Experimental Studies on the Physiology of the Molluscs.—Fourth Paper. (With H. Gideon Wells.) Amer. Jour. Phys., 24, 170. 1909.
The Physiological Significance of Creatin and Creatinin. Science, 29, 584. 1909.
The Absorption of Fats Stained with Sudan III. Amer. Jour. Phys., 24, 493. 1909.
The Paths of Excretion for Inorganic Compounds.—IV. The Excretion of Magnesium. (With Stanley R. Benedict.) Amer. Jour. Phys., 25, 1. 1909.
The Paths of Excretion for Inorganic Compounds.—V. The Excretion of Calcium. (With Stanley R. Benedict.) Amer. Jour. Phys., 25, 23. 1909.
The Relation of the Foodstuffs to Alimentary Functions. Amer. Jour. Med. Sci., October, 1909.
The Iodine Complex in Sponges (3, 5-Diiodtyrosine). (With Henry L. Wheeler.) Jour. Biol. Chem., 7, 1. 1909.
Observations on Vegetable Haemagglutinins. Archivio di Fisiologia, 7, 168. 1909.
The Optical Inactivity of Allantoin. (With H. D. Dakin.) Jour. Biol. Chem., 7, 153. 1910.
The Physiological Utilization of Some Complex Carbohydrates. (With Mary D. Swartz.) Amer. Jour. Med. Sci., March, 1910.
The Metabolism of Some Pyrimidine Derivatives. (With Victor C. Myers.) Amer. Jour. Phys., 26, 77. 1910.
The Physiological Action of Cholin. (With Frank P. Underhill.) Zentralblatt für Physiologie, 24, 251. 1910.
The Metabolism of Some Purine Compounds in the Rabbit, Dog, Pig, and Man. (With John F. Lyman.) Jour. Biol. Chem., 8, 115. 1910.
On the Adaption of the Human Saliva to Diet. (With Jessamine Chapman and Alice F. Blood.) Med. Rec., August 27, 1910.
The Fate of Saccharose after Parenteral Introduction in Animals. (With Israel S. Kleiner.) Amer. Jour. Phys., 26, 396. 1910.
Some Peculiarities of the Proteolytic Activity of Papain. (With Alice F. Blood.) Jour. Biol. Chem., 8, 177. 1910.
The Influence of Alcohol upon Nitrogenous Metabolism in Men and Animals. (With Warren W. Hilditch.) Amer. Jour. Phys., 27, 1. 1910.
Über Jodproteine. (With H. L. Wheeler.) Biochemische Zeitschrift, 29, 417. 1910.
Various articles on physiological chemistry in Buck's Reference Handbook of the Medical Sciences. Wm. Wood & Co. New York.
Feeding Experiments with Mixtures of Isolated Food-Substances. (With Thomas B. Osborne.) Proc. Amer. Phys. Soc., Amer. Jour. Phys., 27, No. 4. February, 1911.
Mucic Acid and Carbohydrate Metabolism. (With William C. Rose.) Proc. Amer. Soc. Biol. Chem., Jour. Biol. Chem., 9, No. 2. April, 1911.
The Behavior of Fat-soluble Dyes in the Organism. (With Amy L. Daniels.) Proc. Soc. Exper. Biol. and Med., 8, 126. 1911.

Some Features of Nutrition during Growth. Jour. Home Econ., 3, 262. 1911.

The Rôle of Carbohydrates in Creatine-Creatinine Metabolism. (With William C. Rose.) Jour. Biol. Chem., 10, 213. 1911.

Inanition and the Creatine Content of Muscle. (With William C. Rose.) Jour. Biol. Chem., 10, 254. 1911.

The Rôle of Different Proteins in Nutrition and Growth. (With Thomas B. Osborne.) Science, 34, 722. 1911.

Theorien des Eiweissstoffwechsels nebst einigen praktischen Konsequenzen derselben. Ergebnisse der Physiologie, 11, 419. 1911.

Feeding Experiments with Isolated Food Substances. (With Thomas B. Osborne.) Carnegie Inst. Wash., Publication 156, Part I, pp. 1-54, 1911; Part II, pp. 55-138. 1911.

The Utilization of the Proteins of Wheat. (With Morris S. Fine.) Jour. Biol. Chem., 10, 303. 1911.

The Utilization of the Proteins of Barley. (With Morris S. Fine.) Jour. Biol. Chem., 10, 339. 1911.

The Utilization of the Proteins of Corn. (With Morris S. Fine.) Jour. Biol. Chem., 10, 345. 1911.

The Utilization of the Proteins of the Legumes. (With Morris S. Fine.) Jour. Biol. Chem., 10, 433. 1911.

The Utilization of the Proteins of Cotton Seed. (With Morris S. Fine.) Jour. Biol. Chem., 11, 1. 1912.

The Utilization of the Proteins of Extractive-free Meat Powder and the Origin of Fecal Nitrogen. (With Morris S. Fine.) Jour. Biol. Chem., 11, 5. 1912.

The Physiological Action of Salts of Choline. (With Frank P. Underhill and R. R. Renshaw.) Jour. Exper. Phar. and Ther. 3, 649-660. 1912.

The Rôle of Proteins in Growth. (With Thomas B. Osborne.) Jour. Biol. Chem., 11, xxii. 1912.

Maintenance and Growth. (With Thomas B. Osborne.) Jour. Biol. Chem., 11, xxxvii. 1912.

Growth and Maintenance on Purely Artificial Diets. (With Thomas B. Osborne.) Proc. Soc. Exper. Biol. and Med., 9, 72. 1912.

Feeding Experiments with Fat-free Food Mixtures. (With Thomas B. Osborne.) Proc. Soc. Exper. Biol. and Med., 9, 73. 1912.

Ein Stoffwechselkäfig und Fütterungsvorrichtungen für Ratten. (With Thomas B. Osborne.) Zeitschrift für biologische Technik, 2, 313-318. 1912.

Feeding Experiments with Fat-free Food Mixtures. (With Thomas B. Osborne.) Jour. Biol. Chem., 12, 81-89. 1912.

The Rôle of Gliadin in Nutrition. (With Thomas B. Osborne.) Jour. Biol. Chem., 12, 473. 1912.

The Behavior of Fat-soluble Dyes and Stained Fat in the Animal Organism. (With Amy L. Daniels.) Jour. Biol. Chem., 13, 71. 1912.

Maintenance Experiments with Isolated Proteins. (With Thomas B. Osborne.) Jour. Biol. Chem., 13, 233. 1912.
Beobachtungen über Wachstum bei Fütterungsversuchen mit isolierten Nahrungssubstanzen. (With Thomas B. Osborne.) Zeitschrift für physiologische Chemie, 80, 307. 1912.
The Rôle of Proteins in Growth. Trans. XV Internat. Cong. Hyg. and Dem., 2, Part 2, 1913.
Feeding Experiments Relating to the Nutritive Value of the Proteins of Maize. (With Thomas B. Osborne.) Amer. Jour. Phys., 31, xvi, Feb., 1913. Also Jour. Biol. Chem., 14, xxxi, March, 1913.
The Physiological Action of Some Methylated Purines. (With R. L. Kahn.) Jour. Pharm. Exper. Ther., 4, 343. 1913.
Diabetic Foods. (With John Phillips Street.) Rep. Conn. Agri. Exper. Sta., Part I, 1-95. 1913.
The Relation of Growth to the Chemical Constituents of the Diet. (With Thomas B. Osborne.) Jour. Biol. Chem., 15, 311-326, Aug., 1913.
The Rate of Elimination of Nitrogen as Influenced by Diet Factors. I. The Influence of the Texture of the Diet. (With Robert C. Lewis.) Jour. Biol. Chem., 16, 19-36, Oct., 1913.
The Rate of Elimination of Nitrogen as Influenced by Diet Factors. II. The Influence of Carbohydrates and Fats in the Diet. (With Robert C. Lewis.) Jour. Biol. Chem., 16, 37-53, Oct., 1913.
The Rate of Elimination of Nitrogen as Influenced by Diet Factors. III. The Influence of the Character of the Ingested Protein. (With Robert C. Lewis.) Jour. Biol. Chem., 16, 55-77, Oct., 1913.
The Influence of Butter-Fat on Growth. (With Thomas B. Osborne.) Jour. Biol. Chem., 16, 423-437, Dec., 1913.
Viewpoints in the Study of Growth. Biochem. Bull., 3, 156-176, Jan., 1914.
Some Problems of Growth. (With Thomas B. Osborne.) Amer. Jour. Phys., 33, xxviii, 1914. Also Jour. Biol. Chem., 17, xxiii, Mar., 1914.
Amino-Acids in Nutrition and Growth. (With Thomas B. Osborne.) Jour. Biol. Chem., 17, 325-349, Apr., 1914.
The Influence of Cod Liver Oil and Some Other Fats on Growth. (With Thomas B. Osborne.) Jour. Biol. Chem., 17, 401-408, Apr., 1914.
The Nutritive Significance of Different Kinds of Food Stuffs. Med. Rec., 85, 737-740, Apr., 1914.
Nutritive Properties of Proteins of the Maize Kernel. (With Thomas B. Osborne). Jour. Biol. Chem., 18, 1-16, June, 1914.
The Suppression of Growth and the Capacity to Grow. (With Thomas B. Osborne.) Jour. Biol. Chem., 18, 95-106, June, 1914.
The Contribution of Bacteria to the Feces After Feeding Diets Free from Indigestible Components. (With Thomas B. Osborne.) Jour. Biol. Chem., 18, 177-182, July, 1914.
Newer Points of View Regarding the Part Played by Different Food Substances in Nutrition. Jour. Amer. Med. Assn., 63, 819-822, Sept., 1914.

Nutrition and Growth. N. Y. Med. Jour., 1168-1169, Dec. 12, 1914.
Continuation and Extension of Work on Vegetable Proteins. (With T. B. Osborne.) Year Book, Carnegie Inst. Wash., No. 13, 364-370. 1914.
The Influence of Beef Fat on Growth. (With Thomas B. Osborne.) Proc. Soc. Exper. Biol. and Med., 12, 92, Jan., 1915.
The Comparative Nutritive Value of Certain Proteins in Growth, and the Problem of the Protein Minimum. (With Thomas B. Osborne.) Jour. Biol. Chem., 20, 351-378, March, 1915.
Further Observations on the Influence of Natural Fats upon Growth. (With Thomas B. Osborne.) Jour. Biol. Chem., 20, 379-389, March, 1915.
Specific Chemical Aspects of Growth. Science, 41, 567, April, 1915.
Nutrition and Growth. Jour. Amer. Med. Assn., 64, 1539-1547, May, 1915.
The Question of Fat Absorption from the Mammalian Stomach. (With Emil J. Baumann.) Jour. Biol. Chem., 22, 165-190, Aug., 1915.
The Rôle of the Digestive Glands in the Excretion of Endogenous Uric Acid. (With Raymond L. Stehle.) Jour. Biol. Chem., 22, 215-231, Aug., 1915.
Protein Minima for Maintenance. (With Thomas B. Osborne.) Jour. Biol. Chem., 22, 241-257, Sept., 1915.
Experimental Observations on Certain Phenomena of Growth. (With Thomas B. Osborne.) Science, 42, 681, Nov. 12, 1915.
The Resumption of Growth after Long Continued Failure to Grow. (With Thomas B. Osborne.) Jour. Biol. Chem., 23, 439-454, Dec., 1915.
Continuation and Extension of Work on Vegetable Proteins. (With T. B. Osborne.) Year Book, Carnegie Inst. Wash., No. 14, 378-384, 1915.
Nutrition and Growth. The Harvey-Lectures 1914-15, Lippincott, Philadelphia, 1915.
The Stability of the Growth-Promoting Substance in Butter Fat. (With Thomas B. Osborne.) Proc. Amer. Soc. Pharm., Dec., 1915.
Growth. (With Thomas B. Osborne.) Jour. Lab. and Clin. Med., I, 211-216, Jan., 1916.
The Stability of the Growth-Promoting Substance in Butter Fat. (With Thomas B. Osborne.) Jour. Biol. Chem., 24, 37-39, Jan., 1916.
Changes in the Food Supply and Their Relation to Nutrition. Yale University Press, Feb., 1916.
Acceleration of Growth after Retardation. (With Thomas B. Osborne.) Amer. Jour. Phys., 40, 16-20, March, 1916.
Some Practical Applications of Feeding Experiments with Albino Rats. (With Thomas B. Osborne.) Proc. Amer. Phys. Soc., Amer. Jour. Phys., 40, 147, March, 1916.
The Amino-Acid Minimum for Maintenance and Growth, as Exemplified by Further Experiments with Lysine and Tryptophane. (With Thomas B. Osborne.) Jour. Biol. Chem., 25, 1-12, May, 1916.

Das Wachstum. Ergebnisse der Physiologie, Wiesbaden, 1916.

Some Relations of Nutrition to Practical Agriculture. Ill. Agri., 20, 684-686, May, 1916.

The Nutritive Value of Some Cotton-Seed Products in Growth. (With Thomas B. Osborne.) Proc. Soc. Exper. Biol. and Med., 13, 147-148. 1916.

A Quantitative Comparison of Casein, Lactalbumin, and Edestin for Growth or Maintenance. (With Thomas B. Osborne.) Jour. Biol. Chem., 26, 1-23, Aug., 1916.

The Regulation of the Blood Volume after Injections of Saline Solutions. Studies of the Permeability of Cellular Membranes. I. (With L. Jean Bogert and Frank P. Underhill.) Amer. Jour. Phys., 41, 189-218, Aug., 1916.

The Action of Saline-Colloidal Solutions upon the Regulation of Blood Volume. Studies of the Permeability of Cellular Membranes. II. (With L. Jean Bogert and Frank P. Underhill.) Amer. Jour. Phys., 41, 219-228, Aug., 1916.

The Influence of Alkaline-Saline Solutions upon Regulation of Blood Volume. Studies of the Permeability of Cellular Membranes. III. (With L. Jean Bogert and Frank P. Underhill.) Amer. Jour. Phys., 41, 229-233, Aug., 1916.

Some New and Important Phases of Nutrition in the Feeding of Farm Animals. Flour, Hay, Grain and Feed, 29, 21-22, Sept., 1916.

The Effect of the Amino-Acid Content of the Diet on the Growth of Chickens. (With Thomas B. Osborne.) Jour. Biol. Chem., 26, 293-300, Sept., 1916.

Some Interrelations Between Diet, Growth, and the Chemical Composition of the Body. (With Sarah E. Judson.) Proc. Nat. Acad. Sci., 2, 692-694, Dec., 1916.

The Growth of Rats upon Diets of Isolated Food Substances. (With Thomas B. Osborne.) Biochem. Jour., 10, 534-538, Dec., 1916.

Continuation and Extension of Work on Vegetable Proteins. (With T. B. Osborne.) Year Book, Carnegie Inst. Wash., No. 15, 365-372. 1916.

Abnormalities of Growth. Amer. Jour. Med. Sci., 153, 1-20, Jan., 1917.

The Relative Value of Certain Proteins and Protein Concentrates as Supplements to Corn Gluten. (With Thomas B. Osborne.) Jour. Biol. Chem., 29, 69-92, Feb., 1917.

The Use of Cotton Seed as Food. (With Thomas B. Osborne.) Proc. Amer. Phys. Soc., Amer. Jour. Phys., 42, 585. 1917.

The Use of Cotton Seed as Food. (With Thomas B. Osborne.) Jour. Biol. Chem., 29, 289-317, March, 1917.

The Effect of Retardation of Growth upon the Breeding Period and Duration of Life of Rats. (With Thomas B. Osborne and Edna L. Ferry.) Science, N. S., 45, 294-295, March, 1917.

The Food Value of Soy Bean Products. (With Thomas B. Osborne.) Proc. Soc. Exper. Biol. and Med., 14, 174-175, May, 1917.

Effect of Ingestion of Coffee, Tea and Caffein on the Excretion of Uric Acid in Man. (With Emma L. Wardell.) Jour. Amer. Med. Assn., 68, 1805, June 16, 1917.

The Physiological Behavior of Raffinose. (With Shigenobu Kuriyama.) Jour. Biol. Chem., 31, 125-147, July, 1917.

The Rôle of Vitamines in the Diet. (With Thomas B. Osborne.) Jour. Biol. Chem., 31, 149-163, July, 1917.

The Incidence of Phosphatic Urinary Calculi in Rats Fed on Experimental Rations. (With Thomas B. Osborne.) Jour. Amer. Med. Assn., 69, 32-33, July 7, 1917.

Studies in Calcium and Magnesium Metabolism. I. The Effects of Base and Acid. (With Maurice H. Givens.) Jour. Biol. Chem., 31, 421-433, Aug., 1917.

Nutritive Factors in Animal Tissues. I. (With Thomas B. Osborne.) Jour. Biol. Chem., 32, 309-323, Dec., 1917.

The Use of Soy Bean as Food. (With Thomas B. Osborne.) Jour. Biol. Chem., 32, 369-387, Dec., 1917.

Continuation and Extension of Work on Vegetable Proteins. (With T. B. Osborne.) Year Book, Carnegie Inst. Wash., No. 16, 324-329, 1917.

Further Observations on the Nutritive Factors in Animal Tissues. (With Thomas B. Osborne.) Proc. Soc. Exper. Biol. and Med., 15, 71, Feb., 1918.

The Growth of Chickens in Confinement. (With Thomas B. Osborne.) Jour. Biol. Chem., 33, 433-438, March, 1918.

The Growth of Chickens under Laboratory Conditions. (With Thomas B. Osborne.) Proc. Amer. Soc. Pharm. and Exper. Ther., Jour. Pharm., 11, 170, 1918.

The Rôle of Some Inorganic Elements in Nutrition. (With Thomas B. Osborne.) Proc. Amer. Soc. Biol. Chem., Jour. Biol. Chem., 33, iii. March, 1918.

An Experimental Study of Alternating Growth and Suppression of Growth in the Albino Mouse, with Special Reference to the Economy of Food Consumption. (With Helen B. Thompson.) Amer. Jour. Phys., 45, 431-460, March, 1918.

Nutritive Factors in Animal Tissues. II. (With Thomas B. Osborne.) Jour. Biol. Chem., 34, 17-27, April, 1918.

The Inorganic Elements in Nutrition. (With Thomas B. Osborne.) Jour. Biol. Chem., 34, 131-139, April, 1918.

Diet and Roughage in Relation to the Experimental Scurvy of Guinea Pigs. (With Barnett Cohen.) Proc. Soc. Exper. Biol. and Med., 15, 122-123, May, 1918.

The Protein Factor in Nutrition. Prepared for "The Army Book of Nutrition," Food Division, Sanitary Corps, Medical Department, United States Army, 1918.

Nutritive Factors in Plant Tissues. I. The Protein Factor in the Seeds of Cereals. (With Thomas B. Osborne.) Jour. Biol. Chem., 34, 521-535, June, 1918.
Milk as a Source of Water-Soluble Vitamine. I. (With Thomas B. Osborne.) Jour. Biol. Chem., 34, 537-551, June, 1918.
The Choice Between Adequate and Inadequate Diets, as Made by Rats. (With Thomas B. Osborne.) Jour. Biol. Chem., 35, 19-27, July, 1918.
Experiments on the Utilization of Nitrogen, Calcium, and Magnesium in Diets Containing Carrots and Spinach. (With Harry B. McClugage.) Jour. Biol. Chem., 35, 353-366, Aug., 1918.
Experimental Scurvy of the Guinea Pig in Relation to the Diet. (With Barnett Cohen.) Jour. Biol. Chem., 35, 425-453, Sept., 1918.
Vitamines in Green Leaves. (With Thomas B. Osborne.) Proc. Soc. Exper. Biol. and Med., 16, 15-16, Nov., 1918.
Continuation and Extension of Work on Vegetable Proteins. (With T. B. Osborne.) Year Book, Carnegie Inst. Wash., No. 17, 302-310, 1918.
Chapter on "Milk and Its Products." "The Day's Food in War and Peace," United States Food Administration, 1918.
The Vitamines in Green Foods. (With Thomas B. Osborne.) Jour. Biol. Chem., 37, 187-200, Jan., 1919.
A Method of Expressing Numerically the Growth-Promoting Value of Proteins. (With Thomas B. Osborne and Edna L. Ferry.) Jour. Biol. Chem., 37, 223-229, Feb., 1919.
The Extraction of "Fat-Soluble Vitamine" from Green Foods. (With Thomas B. Osborne.) Proc. Soc. Exper. Biol. and Med., 16, 98-99, Mar., 1919.
The Nutritive Value of the Wheat Kernel and Its Milling Products. (With Thomas B. Osborne.) Jour. Biol. Chem., 37, 557-601, April, 1919.
The Nutritive Value of Yeast Protein. (With Thomas B. Osborne.) Jour. Biol. Chem., 38, 223-227, June, 1919.
Nutritive Factors in Plant Tissues. II. The Distribution of Water-Soluble Vitamine. (With Thomas B. Osborne.) Jour. Biol. Chem., 39, 29-34, August, 1919.
Food Factors in Gastro-Enterology. Amer. Jour. Med. Sci., 158, 297-307, Sept., 1919.
Do Fruits Contain Water-Soluble Vitamine? (With Thomas B. Osborne.) Proc. Soc. Exper. Biol. and Med., 17, 46-47, Nov., 1919.
Des Rapports du Régime Alimentaire et de la Maladie. Bulletin de la Société Scientifique d'Hygiène Alimentaire et d'Alimentation Rationelle de l'Homme, 7, 194-198, 1919.
Les Facteurs Alimentaires en Gastro-Entérologie. Bulletin de la Société Scientifique d'Hygiène Alimentaire et d'Alimentation Rationelle de l'Homme, 7, 540-551, 1919.

Continuation and Extension of Work on Vegetable Proteins. (With T. B. Osborne.) Year Book, Carnegie Inst. Wash., No. 18, 352-360, 1919.

Nutritive Value of the Proteins of the Barley, Oat, Rye, and Wheat Kernels. (With Thomas B. Osborne.) Jour. Biol. Chem., 41, 275-306, March, 1920.

Nutritive Factors in Plant Tissues. III. Further Observations on the Distribution of Water-Soluble Vitamine. (With Thomas B. Osborne.) Jour. Biol. Chem., 41, 451-468, March, 1920.

Fat-Soluble Vitamine of Green Foods. (With Thomas B. Osborne.) Proc. Amer. Soc. Biol. Chem., Jour. Biol. Chem., 41, vii, March, 1920.

Nutritive Factors in Plant Tissues. IV. Fat-Soluble Vitamine. (With Thomas B. Osborne.) Jour. Biol. Chem., 41, 549-565, April, 1920.

Milk as a Source of Water-Soluble Vitamine. II. (With Thomas B. Osborne.) Jour. Biol. Chem., 41, 515-523, April, 1920.

The Effect of Solutions of Certain Salts and Colloids on the Permeability of the Capillary Walls. (With Arthur H. Smith.) Proc. Soc. Exper. Biol. and Med., 17, 201, May, 1920.

The Fat-Soluble Vitamine. N. Y. State Jour. Med., 20, 212-217, July, 1920.

The Occurrence of Water-Soluble Vitamine in Some Common Fruits. (With Thomas B. Osborne.) Jour. Biol. Chem., 42, 465-489, July, 1920.

The Adjustment of Blood Volume After Injection of Isotonic Solutions of Varied Composition. (With Arthur H. Smith.) Amer. Jour. Phys., 53, 323-344, Sept., 1920.

Studies on Carbohydrate Metabolism in Rabbits. I. Observations on the Limits of Assimilability of Various Carbohydrates. (With Martha R. Jones.) Jour. Biol. Chem., 43, 491-506, Sept., 1920.

Skimmed Milk as a Supplement to Corn in Feeding. (With Thomas B. Osborne.) Jour. Biol. Chem., 44, 1-4, Oct., 1920.

Growth on Diets Poor in True Fats. (With Thomas B. Osborne.) Jour. Biol. Chem., 45, 145-152, Dec., 1920.

Comparative Studies on the Physiological Value and Toxicity of Cotton Seed and Some of Its Products. (With Icie G. Macy.) Jour. Pharm. and Exper. Ther., 16, 345-390, Dec., 1920.

Continuation and Extension of Work on Vegetable Proteins. (With T. B. Osborne.) Year Book, Carnegie Inst. Wash., No. 19, 389-401, 1920.

A Critique of Experiments with Diets Free From Fat-Soluble Vitamine. (With Thomas B. Osborne.) Jour. Biol. Chem., 45, 277-288, Jan., 1921.

Does Growth Require Preformed Carbohydrate in the Diet? (With Thomas B. Osborne.) Proc. Soc. Exper. Biol. and Med., 18, 136-137, Feb., 1921.

Growth on Diets Containing More Than Ninety Per Cent of Protein. (With Thomas B. Osborne.) Proc. Soc. Exper. Biol. and Med., 18, 167-168, March, 1921.

Ophthalmia and Diet. (With Thomas B. Osborne.) Jour. Amer. Med. Assn., 76, 905-908, April 2, 1921.

Feeding Experiments with Mixtures of Foodstuffs in Unusual Proportions. (With Thomas B. Osborne.) Proc. Nat. Acad. Sci., 7, 157-162, June, 1921.

Chemical Factors in Nutrition. Jour. Franklin Inst., July, 1921.

Studies in the Physiology of Vitamins. I. Vitamin-B and the Secretory Function of Glands. (With George R. Cowgill.) Amer. Jour. Phys., 58, 131-151, Nov., 1921.

Studies in Nutrition. The Choice between Adequate and Inadequate Diet, as Made by Rats and Mice. (With Helen S. Mitchell.) Amer. Jour. Phys., 58, 211-225, Dec., 1921.

Continuation and Extension of Work on Vegetable Proteins. (With T. B. Osborne.) Year Book, Carnegie Inst. Wash., No. 20, 432-441, 1921.

Vitamine A in Oranges. (With Thomas B. Osborne.) Proc. Soc. Exper. Biol. and Med., 19, 187-188, Jan., 1922.

Nutritive Factors in Plant Tissues. V. Further Observations on the Occurrence of Vitamin B. (With Thomas B. Osborne.) Proc. Soc. Exper. Biol. and Med., 19, 291-292, March, 1922.

Further Observations on the Distribution of Vitamin B in Some Vegetable Foods. (With Thomas B. Osborne.) Jour. Amer. Med. Assn., 78, 1121-1122, April 15, 1922.

Quelques caracteristiques d'ordre chimique de l'alimentation. (With T. B. Osborne.) Bulletin de la Société Scientifique d'Hygiene Alimentaire, 10, 5-11, 1922.

A Comparison of the Nitrogenous Metabolism During Single and Fractional Feedings. (With Alfred Chanutin.) Jour. Metabolic Res., 1, 1-8, April, 1922.

Experimental Evidence of the Lack of Vitamin B in Nutrition. Trans. Congress Amer. Phys. and Sur., 12, 15-22, May, 1922.

Milk as a Source of Water-Soluble Vitamin. III. (With Thomas B. Osborne.) Biochemical Jour., 16, 363-367, 1922.

The Distribution of Vitamin B in the Wheat Kernel. (With Marion Bell.) Amer. Jour. Phys., 62, 145-161, Sept., 1922.

Quantitative Aspects of the Rôle of Vitamine B in Nutrition. (With Thomas B. Osborne.) Jour. Biol. Chem., 54, 739-752, Dec., 1922.

Continuation and Extension of Work on Vegetable Proteins. (With T. B. Osborne.) Year Book, Carnegie Inst. Wash., No. 21, 373-381, 1922.

Eggs as a Source of Vitamin B. (With Thomas B. Osborne.) Jour. Amer. Med. Assn., 80, 302-303, Feb. 3, 1923.

Experiments on the Metabolism of Thymine. (With Harry J. Deuel, Jr.) Proc. Soc. Exper. Biol. and Med., 20, 237, Feb., 1923.

Kidney Hypertrophy Produced by Diets Unusually Rich in Protein. (With Thomas B. Osborne, Edwards A. Park and D. Darrow.) Proc. Soc. Exper. Biol. and Med., 20, 452-453, May, 1923.

Experimental Production of Rickets with Diets of Purified Food Substances. (With Thomas B. Osborne and Edwards A. Park.) Proc. Soc. Exper. Biol. and Med., 21, 87-90, Nov., 1923.
The Effect of Diet on the Content of Vitamine B in the Liver. (With Thomas B. Osborne.) Jour. Biol. Chem., 58, 363-367, Dec., 1923.
Temperature Variations in Rabbits. (With Florence B. Seibert.) Amer. Jour. Phys., 67, 83-89, Dec., 1923.
Protein Fevers. (With Florence B. Seibert.) Amer. Jour. Phys., 67, 105-123, Dec., 1923.
Nutrition: The Chemistry of Life. Yale University Press, 1923.
Continuation and Extension of Work on Vegetable Proteins. (With T. B. Osborne.) Year Book, Carnegie Inst. Wash., No. 22, 340-346, 1923.
Nutrition and Growth on Diets Highly Deficient or Entirely Lacking in Preformed Carbohydrates. (With Thomas B. Osborne.) Jour. Biol. Chem., 59, 13-32, Feb., 1924.
Nutrition and Growth on Diets Highly Deficient or Entirely Lacking in Preformed Carbohydrates. (With Thomas B. Osborne.) Proc. Amer. Soc. Biol. Chem., Jour. Biol. Chem., 59, xliv, Feb., 1924.
Nutrition and Growth on Diets Highly Deficient or Entirely Lacking in Preformed Carbohydrates. (With Thomas B. Osborne.) Proc. Amer. Phys. Soc., Amer. Jour. Phys., 68, 143, 1924.
Evidence experimentale du manque de vitamine dans l'alimentation. Bulletin de la Société Scientifique d'Hygiène Alimentaire, 12, 29-37, 1924.
The Nutritive Value of Lactalbumin. (With Thomas B. Osborne.) Jour. Biol. Chem., 59, 339-345, March, 1924.
Factors Concerned in Blood Volume Regulation. (With Alfred Chanutin and Arthur H. Smith.) Amer. Jour. Phys., 68, 444-460, May, 1924.
Milk as a Food. Proc. World's Dairy Congress of 1923. 1, 438-444, 1924.
Ophthalmia as a Symptom of Dietary Deficiency. (With Thomas B. Osborne.) Amer. Jour. Phys., 69, 543-547, Aug., 1924.
Continuation and Extension of Work on Vegetable Proteins. (With T. B. Osborne.) Year Book, Carnegie Inst. Wash., No. 23, 286-290, 1924.
Le Lait, en tant qu'aliment. Bulletin de la Société Scientifique d'Hygiène Alimentaire, 13, 147-157, 1925.
Variations in the Kidney Related to Dietary Factors. (With Thomas B. Osborne, Edwards A. Park and Milton C. Winternitz.) Amer. Jour. Phys., 72, 222, March, 1925.
The Rôle of Vitamine B in Relation to the Size of Growing Rats. (With Thomas B. Osborne.) Jour. Biol. Chem., 63, 233-238, March, 1925.
The Effective Agent in the Prevention or Alleviation of the Chittenden-Underhill Pellagra-Like Syndrome in Dogs. (With Frank P. Underhill.) Public Health Reports, 40, 1087-1089, June, 1925.
Continuation and Extension of Work on Vegetable Proteins. (With T. B. Osborne.) Year Book, Carnegie Inst. Wash., No. 24, 286-290. 1925.

The Distribution of Vitamin B in the Maize Kernel. (With Hilda M. Croll.) Amer. Jour. Phys., 74, 674-694, Nov., 1925.
Nitrogen and Sulfur Metabolism in the Dog. (With Marion Fay.) Amer. Jour. Phys., 75, 308-329, Jan., 1926.
The Acceleration of Growth. (With Thomas B. Osborne.) Science, 63, 528-529, May 21, 1926.
The Effects of Radiations from a Quartz Mercury Vapor Arc upon Some Properties of Proteins. (With Hazeltene L. Stedman.) Amer. Jour. Phys., 77, 199-210, June, 1926.
The Relation of the Rate of Growth to Diet. I. (With Thomas B. Osborne.) Jour. Biol. Chem., 69, 661-673, Aug., 1926.
Diet and Body Fat. (With William E. Anderson.) Science, 64, 384-386, Oct. 15, 1926.
Diet and Body Fat. (With W. E. Anderson.) Jour. Oil and Fat. Ind., 3, 396-400, 1926.
Continuation and Extension of Work on Vegetable Proteins. (With T. B. Osborne.) Year Book, Carnegie Inst. Wash., No. 25, 391-397, 1925-26.
Physiological Effects of Diets Unusually Rich in Protein or Inorganic Salts. (With Thomas B. Osborne, Edwards A. Park, and Milton C. Winternitz.) Jour. Biol. Chem., 71, 317-350, Jan., 1927.
Interrelationships Between the Chemical Composition of the Blood and the Lymph of the Dog. (With Rossleene M. Arnold.) Jour. Biol. Chem., 72, 189-211, March, 1927.
The Effects of Dietary Deficiencies on the Growth of Certain Body Systems and Organs. (With Jet C. Winters and Arthur H. Smith.) Amer. Jour. Phys., 80, 576-593, May, 1927.
Some Tendencies in the Promotion of Chemical Research. Science, 65, 559-564, June 10, 1927.
The Transportation and Elimination of Organic Dyes by the Animal Organism. (With Mildred R. Ziegler.) Amer. Jour. Phys., 82, 299-317, Oct., 1927.
Zinc and Normal Nutrition. (With Rebecca B. Hubbell.) Jour. Biol. Chem., 75, 567-586, Nov., 1927.
The Relation of the Rate of Growth to Diet. II. (With Helen C. Cannon.) Jour. Biol. Chem., 75, 779-787, Dec., 1927.
Continuation and Extension of Work on Vegetable Proteins. (With T. B. Osborne.) Year Book, Carnegie Inst. Wash., No. 26, 351-358, 1926-27.
A Dietary Deficiency Canine Disease—Further Experiments on the Diseased Condition in Dogs Described as Pellagra-Like by Chittenden and Underhill and Possibly Related to So-Called Black-Tongue. (With Frank P. Underhill.) Amer. Jour. Phys., 83, 589-633, Jan., 1928.
The Relation of Diet to the Quality of Fat Produced in the Animal Body. (With William E. Anderson.) Jour. Biol. Chem., 76, 729-747, March, 1928.

Continuation and Extension of Work on Vegetable Proteins. (With T. B. Osborne.) Year Book, Carnegie Inst. Wash., No. 27, 369-375, 1927-28.

The Nutritive Value of the Wheat Kernel and Its Milling Products. (With T. B. Osborne.) Leopoldina Amerikaband, 4, 72-115, 1929.

"Synthetic Cod Liver Oil." Indus. and Eng. Chem., 7, 11, March, 1929.

The Iodine Values of "Physiological" or "Synthetic" Rat Fat. (With Ava Josephine McAmis and William E. Anderson.) Proc. Soc. Exper. Biol. and Med., 26, 515-516, March, 1929.

An Attempt to Secure "Refection" in Rats. (With Hubert B. Vickery.) Proc. Soc. Exper. Biol. and Med., 26, 552-555, April, 1929.

Thomas B. Osborne—1859-1929. Amer. Jour. Sci., 17, April, 1929.

The Work of Thomas Burr Osborne (1859-1929). (With Hubert B. Vickery.) Science, 69, 385-389, April, 1929.

Growth of Rats on "Fat-Free" Diets. (With Ava Josephine McAmis and William E. Anderson.) Jour. Biol. Chem., 82, 247-262, May, 1929.

Plant Hemagglutinins with Special Reference to a Preparation from the Navy Bean. (With Verz R. Goddard.) Jour. Biol. Chem., 82, 447-463, May, 1929.

The Utilization of Fatty Oils Given Parenterally. (With Martha Koehne.) Jour. Nutrition, 1, 399-443, May, 1929.

The Vitamin B and the Vitamin G Requirements of the Albino Mouse. (With Franklin C. Bing.) Jour. Nutrition, 2, 49-58, Sept., 1929.

The Production of Edema and Serum Protein Deficiency in White Rats by Low Protein Diets. (With R. A. Frisch and J. P. Peters.) Jour. Biol. Chem., 84, 167-177, Oct., 1929.

Continuation and Extension of Work on Vegetable Proteins. (With H. B. Vickery.) Year Book, Carnegie Inst. Wash., No. 28, 367-377, Dec., 1929.

Praktisches Verfahren bei Ernährungsversuchen. (With A. H. Smith.) Abderhalden's Handbuch der biologischen Arbeitsmethoden, Abt. 4, Teil 13, 117-172, 1930.

Studies in the Physiology of Vitamins. IX. Hemoglobin, Sugar and Chloride Changes in the Blood of Vitamin B-Deficient Rats. (With William B. Rose and Charles J. Stucky.) Amer. Jour. Phys., 91, 520-530, Jan., 1930.

Factors Influencing the Distribution and Character of Adipose Tissue in the Rat. (With L. L. Reed, F. Yamaguchi, and W. E. Anderson.) Jour. Biol. Chem., 87, 147-174, May, 1930.

Effect of Continued Administration of Iodide on the Growth of the Albino Rat. (With Hubert Bradford Vickery.) Proc. Soc. Exper. Biol. and Med., 27, 806-809, May, 1930.

Diet and Tissue Growth. VII. Response to High Protein Diets and Unilateral nephrectomy during Reproduction and Lactation in the Rat, with Particular Reference to Kidney Changes in both Mother and Offspring.

(With H. T. Parsons, A. H. Smith and T. S. Moise.) Archiv. Path., 10, 1-22, July, 1930.
The Vitamins of Water Cress (Nasturtium Officinale). (With H. B. Vickery and H. C. Cronin.) Jour. Home Econ., 22, No. 7, July, 1930.
Lipodystrophy from Insulin Injections. (With L. L. Reed and W. E. Anderson.) Jour. Amer. Med. Assn., 95, 395-396, August 9, 1930.
The Metabolism of the Albino Rat during Prolonged Fasting at Two Different Environmental Temperatures. (With K. Horst and F. G. Benedict.) Jour. Nutrition, 3, No. 2, September, 1930.
Nutrition—Continuation and Extension of Work on Vegetable Proteins. (With H. B. Vickery.) Year Book, Carnegie Inst. Wash., No. 29, 380-389, December 11, 1930.
Some Relations of Diet to Fat Deposition in the Body. (With W. E. Anderson.) Yale Jour. Biol. & Med., 3, No. 2, December, 1930.
The Relation between Anorexia, Anhydremia and Gastric Atony in Dogs Deprived of Water. (With W. B. Rose, C. J. Stucky and G. R. Cowgill.) Amer. Jour. Phys., 96, 132, January, 1931.
Nutrition. United States Daily, April 6, 1931.
New Haven's Food Safeguarded. Health, 58, No. 5, May, 1931.
Optimal Growth. Report of White House Conference on Child Health and Protection.
The Relationship between Food and Water Intakes in Mice. (With F. C. Bing.) Amer. Jour. Phys., 98, 169-179, August, 1931.
Discussion of "Relationship between Diet and Dental Caries." Jour. Dental Res., 11, 562, August, 1931.
The Problem of Pasteurized Milk. Health, Monthly Bull., New Haven Dept. Health, 58, 3, September, 1931.
Continuation and Extension of Work on Vegetable Proteins. (With H. B. Vickery.) Year Book, Carnegie Inst. Wash., No. 30, 1930-31, 430-441. Issued December 10, 1931.
Nutritive Properties of the Seed of the Tobacco Plant (Nicotiana tabacum). (With H. B. Vickery.) Proc. Soc. Exper. Biol. & Med., 29, 290-291, December, 1931.
Factors Influencing the Distribution and Character of Adipose Tissue in the Rat. II. The Effect of Ovariectomy and of Feeding with Thyroxine. (With L. L. Reed and W. E. Anderson.) Jour. Biol. Chem., 96, 313. 1932.
Vitamin A. Jour. Amer. Med. Assn., 98, 1981, June 4, 1932.
Chemical Investigations of the Tobacco Plant. III. Tobacco Seed. Part I. The Nutritive Properties of Tobacco Seed. (With H. B. Vickery.) Conn. Agri. Exp. Sta. Bull. 339, 609-624, June, 1932.
The Changing Diet of the American People. Jour. Amer. Med. Assn., 99, 117-120, July 9, 1932.
The Administration of Ferrous Iodide and Linoleic Acid to Rats Deprived of Vitamin A. (With L. L. Reed and H. B. Vickery.) Science, 76, 300-301, September 30, 1932.

Graham Lusk (Obituary). Scientific Monthly, 281, September, 1932.

Contributor to White House Conference on Child Health and Protection, Growth and Development of the Child. Part III. Nutrition. Century Company, New York, 1932.

Scientific Experiment and Medicine. Science, 76, 393-400, November 4, 1932.

The Heat Production of Unusually Large Rats during Prolonged Fasting. (With F. G. Benedict and K. Horst.) Jour. Nutrition, 5, 581-597, November, 1932.

The Nutritive Properties of the "Crop-Milk" of Pigeons. (With L. L. Reed and H. B. Vickery.) Amer. Jour. Phys., 102, 285-292, November, 1932.

Relations entre le Régime Alimentaire et le Dépot de Graisses dans l'Organisme. (With collaboration of W. E. Anderson.) Reprinted from Bull. de la Soc. Scientifique d'Hygiene Alimentaire, Nos. 3 and 4, 20, 101-199, 1932.

Nutrition. Continuation and Extension of Work on Vegetable Proteins. (With H. B. Vickery.) Year Book, Carnegie Inst. Wash., No. 31, 1931-32, 314-321. Issued Dec. 9, 1932.

The Rate of Growth. I. Its Influence on the Skeletal Development of the Albino Rat. (With J. Outhouse.) Jour. Exp. Zool., 64, 257-285, January 5, 1933.

A Study of Blood Volume Regulation and Blood Composition in Experimental Hydremia. I. The Regulation of Blood Volume. (With D. B. Calvin and A. H. Smith.) Amer. Jour. Phys., 105, 135-145, July, 1933.

The Outlook in the Science of Nutrition. Science, 78, 317-322, October 13, 1933.

Growth of Rats Fed High Protein Rations Supplemented by Different Amounts and Combinations of Vitamins B (B_1), G (B_2), and B Complex. (With L. D. Francis and A. H. Smith.) Jour. Nutrition, 6, 493-505, November, 1933.

Continuation and Extension of Work on Vegetable Proteins. (With H. B. Vickery.) Year Book, Carnegie Inst. Wash., No. 32, 309-317, 1932-33. Issued December 15, 1933.

The Influence of Previous Exercise upon the Metabolism, the Rectal Temperature, and the Body Composition of the Rat. (With K. Horst and F. G. Benedict.) Jour. Nutrition, 7, 251-275, March 10, 1934.

The Effects of Some External Factors upon the Metabolism of the Rat. (With K. Horst and F. G. Benedict.) Jour. Nutrition, 7, 277-303, March 10, 1934.

The Influence of Cholesterol on the Tissues of Rats Ingesting Diets Rich and Poor in Fat. (With H. H. Williams and W. E. Anderson.) Jour. Nutrition, 7, Proceedings, 14, 1934.

The Influence of Previous Diet, Growth and Age upon the Basal Metabolism of the Rat. (With K. Horst and F. G. Benedict.) Jour. Nutrition, 8, 139-162, August, 1934.

Nutrition. Continuation and Extension of Work on Vegetable Proteins. (With H. B. Vickery.) Year Book, Carnegie Inst. Wash., No. 33, 289-295, 1933-34. Issued Dec. 1934.

Cholesterol Metabolism in Rats Ingesting High Carbohydrate Diets. (With H. H. Williams and W. E. Anderson.) Abstr., 89th meeting, Amer. Chem. Soc., Div. Biol. Chem., New York City, April 22-26, 1935.

Determination and Metabolism of Citric Acid. (With C. C. Sherman and A. H. Smith.) Annual meeting, Federation Amer. Soc. Exp. Biol., April 10-13, 1935, Detroit, Mich.

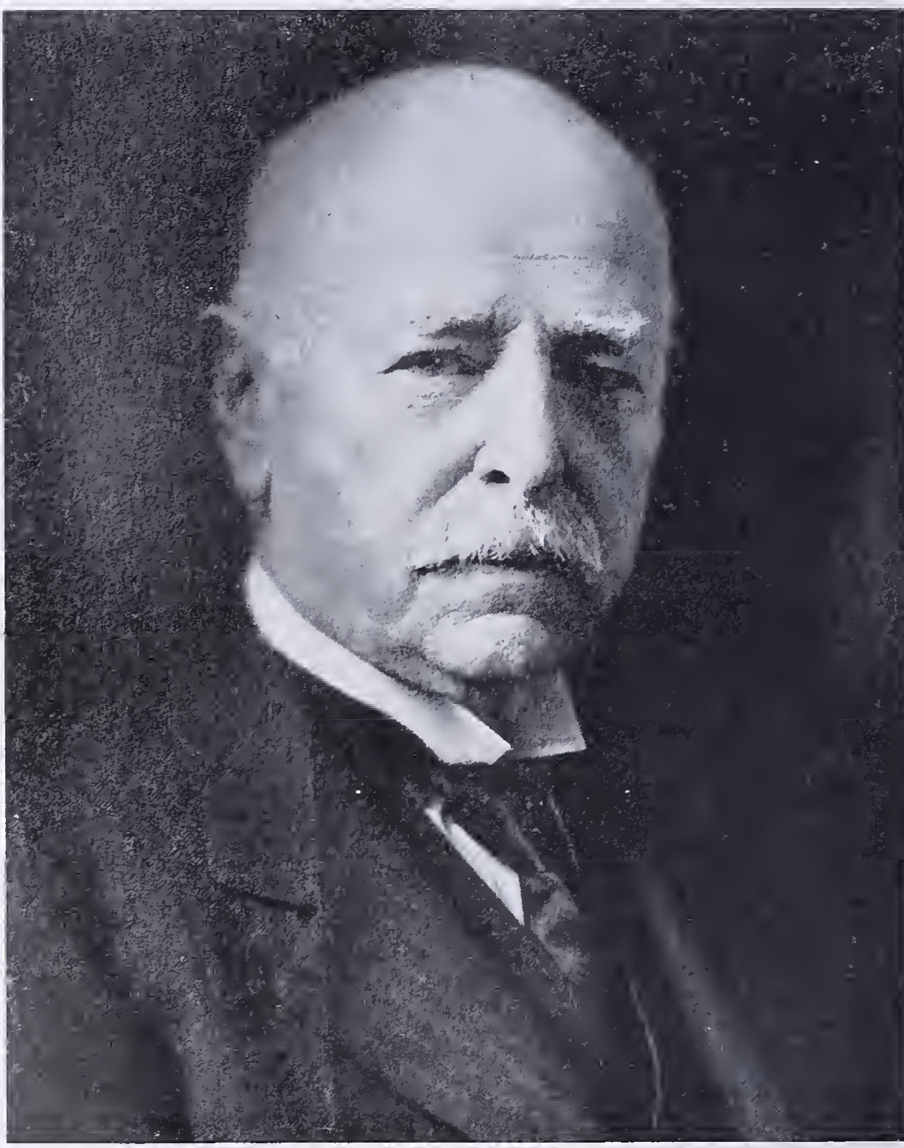
The Influence of Some Commonly Used Salt Mixtures upon Growth and Bone Development of the Albino Rat. (With R. B. Hubbell and A. J. Wakeman.) Annual meeting, Amer. Inst. Nutrition, April 10, 1935, Detroit, Mich.

Relation of Calcium to Blood Formation. (With J. M. Orten and A. H. Smith.) Proc. Soc. Exp. Biol. and Med., 32, 1093-1095, 1935.

Fields of Research in Nutrition. Jour. Home Econ., 27, 415-420, Sept. 1935.

The Relation of the Rate of Growth to Diet. III. A Comparison of Stock Rations Used in the Breeding Colony at the Connecticut Agricultural Experiment Station. (With R. B. Hubbell.) Jour. Nutrition, 10, 557-563, November, 1935.

The Effect of Cereal Diets on the Composition of the Body Fat of the Rat. (With H. S. Olcott and W. E. Anderson.) Jour. Nutrition, 10, 517-523, November, 1935.



W. T. Councilman

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OF

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1854–1933

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WILLIAM THOMAS COUNCILMAN

1854–1933

BY HARVEY CUSHING

Throughout his long life Councilman was a man of ardent and generous enthusiasms. It was this quality, combined with his utter informality, which made him such an inspiring teacher for the young and such a delightful companion both for young and old. There was a picturesque ruggedness in his personal appearance, an unexpectedness in his turn of thought, a shrewdness and independence in his observations concerning people, things and events that set him apart from the common mould. He had escaped from early educational and environmental inhibitions by which many persons come to be afflicted and subdued. Combined with an utter unconsciousness of self, there was about him a certain sturdiness of mind, frankness of opinion and honesty of purpose which were no less disconcerting to the self-complacent than refreshing to those who appreciated his outspoken sincerity.

He was born on a busy farm which straddled the Reistertown turnpike not far from Baltimore, and he always regarded it as fortunate that his early years were passed in such an environment. There he learned to plow, to swing a cradle, to bind sheaves of grain and do other things that were unforgettable, like the gathering of spring simples.

"The earliest of my childhood recollections" [he wrote in one of his later-year addresses] "is being taken by my grandfather when he set out in the first warm days of early spring with a grubbing hoe (we called it a mattock) on his shoulder to seek the plants, the barks and roots from which the spring medicine for the household was prepared. If I could but remember all that went into that mysterious decoction and the exact method of preparation, and with judicious advertisement put the product upon the market, I would shortly be possessed of wealth which might be made to serve the useful purpose of increasing the salaries of all pathologists. . . . But, alas! I remember only that the basic ingredients were dogwood bark and sassafras root, and to these were added *qu. s.* bloodroot, poke and yellow dock.

That the medicine benefited my grandfather I have every reason to believe, for he was a hale, strong old man, firm in body and mind until the infection came against which even spring medicine was of no avail. That the medicine did me good I well know, for I can see before me even now the green on the south hillside of the old pasture, the sunlight in the strip of wood where the dogwood grew, the bright blossoms and the delicate pale green of the leaf of the sanguinaria, and the even lighter green of the tender buds of the sassafras in the hedgerow, and it is good to have such pictures deeply engraved in the memory."

Sent off to school at St. John's College, Annapolis, he left there at the age of sixteen and for the next six years "led an independent existence, raised side whiskers, considered himself a very ripe individual and did pretty much as he chose." That he was always something of a rebel and disinclined to do anything which did not interest him, he in after years frequently confessed. But at the age of twenty-two, the determination struck him to follow in the footsteps of his father, a country doctor "who had never lost the childish desire to find things out by observation and the test of experiment."

He entered the Medical School of the University of Maryland which was no better nor worse than most schools of the period, the two-year course consisting largely of a series of lectures. The dissecting room, however, provided the contact with Nature for which he yearned, and the form and structure of the body soon fired his curiosity. Fully to satisfy this, the farm provided an excellent opportunity and, beginning with the mole, he proceeded to make a comparative study of the skulls of all available animals until the collection finally threatened to crowd him out of his bedroom. So engrossed did he become in this occupation he largely neglected his second-year course of lectures; and it was not wholly a misfortune that one day during his absence a little nephew "with a good business head" sold the whole collection for a few cents to an itinerant bone merchant. This grievous episode, by driving him back to his lectures, made it possible for him to attain, in March of 1878, the degree "qualifying him to exercise the art of medicine which he had so laboriously learned for the advantage of the public."

Then something notable happened and what this was can be best told fragmentarily in his own words, though properly to do so the scene must be shifted and the calendar advanced to 1921, a full forty-three years.

As the Christmas recess drew near, it was noised about in the Harvard Medical School that on December 19th Professor Councilman was for the last time to conclude his course of lectures on pathology for the second-year class. Entering the large amphitheater to find it packed to the doors by members of all classes, his face became suffused at the burst of applause and then, abandoning his intended discourse, with his engaging hesitancy of speech slightly more pronounced than usual, he said in effect:

"It is plain to see that you regard this as an occasion marking an epoch in my life, and there is a tendency to regard an epoch as an excuse for remarks. The three great epochs of life are birth, marriage and death, and they are often accompanied by certain remarks. At the wedding breakfast many have suffered from these remarks and some of us have made them. The present is a sort of intermediate epoch and though my talk is usually desultory I may take advantage of the occasion to be even more vague and desultory than usual."

By good fortune someone wrote down his impromptu ruminations and though they can not be quoted in full, interesting as that would be, some excerpts will serve to show what it was that happened after his graduation in March of 1878.

> . . . I heard that there was at the Johns Hopkins University a new sort of institution called a laboratory. I vaguely knew of the Johns Hopkins University but not a great deal about it. It had opened in 1876 and Huxley came on to give the opening address; my father drove in from the country and heard this address and he came back and told us what an impression it had made on him. . . . There seems something remarkable about the opening of this University. . . . The men, Martin, Rowland, Brooks, and Remsen, were young men, and as young men they felt no hampering traditions. Traditions may be very important, but they can be extremely hampering as well, and whether or not tradition is of really much value I have never been certain. Of course when they are very fine, they do good,

but it is very difficult of course ever to repeat the conditions under which good traditions are formed, so they may be and are often injurious and I think the greatest progress is made outside of traditions. So the Johns Hopkins University started without traditions, and started with young men, full of vigor and enthusiasm, as its leaders. The University at its beginning made provision for twenty fellowships, each fellow being paid five hundred dollars; and *the idea of going to a university and being paid for it* made an impression!

He then went on to tell of Martin's permitting him to join his small class in the biological laboratory for the next three months and how thrilled he was with the informal spirit of the place and with the method of teaching through observation and experiment. That summer he became assistant to the quarantine officer, bought a cheap microscope with his first small earnings, and began with its aid to study such histological preparations as he could find time to make in the intervals of his routine work. And when that autumn Martin offered him the assistantship in physiology for the following year his cup was overflowing.

For the first paper he ever wrote (an experimental study of inflammation of the cornea) he was given a prize of one hundred dollars and with this encouragement he might well enough have been tempted to take up biology as a career. But something else proved a greater lure: for during the summer months of the three years since his graduation he had been at work, partly at the Marine Hospital and partly at the Bayview Asylum (the city almshouse and hospital) meanwhile becoming ardently interested in histological pathology. Properly to pursue this subject further, he decided that he must go abroad, which his frugal savings permitted him inexpensively to do.

He could scarcely have gone at a more fortunate time, for almost daily new discoveries were being made and new methods developed. In 1880 German medicine was approaching its heyday, under the stimulus of the new cellular pathology and the cultivation of pathogenic bacteria, both greatly aided by the increasing use of analine dyes in the study of tissues and micro-organisms. His longest sojourn was passed in Vienna

under men who had been brought up in the tradition of Rokitansky. For a considerable time he was with Recklinghausen in the new school at Strassburg. He was working under Cohnheim and Weigert in their active laboratory at Leipzig when in April 1882 the exciting news was brought of Koch's discovery of the tubercule bacillus. And a year later he is found with Hans Chiari, a man of his own age, whom he had first known in Vienna but who now held the chair of pathology in Prague. From this place under the date of July 16, 1883 a certain "correspondent," W.T.C., sent off to the *Medical News* an entertaining letter largely given over to a vivid description of the ordinary mid-day meal served in that part of the world.

So in his final lecture—to which, from this digression we may again turn—he went on to say:

> I came back from Europe very full of all the things which I had learned and with a more or less definite idea of . . . practising medicine. But I put off later and later the putting up of a sign showing that I was willing to serve, and finally never put it out, because it seemed to me there were so many other interesting things to do. And as long as one saw the possibility of doing these interesting things without actual starvation, there was no question of the choice, and there should never be a question of the choice. I reasoned that if worse came to worst I had a few acres of good land on which I could raise all the food I required and something over, . . . but I never had to resort to agriculture for a living. I speak of this because at that time there seemed to be no possibility of earning a living by teaching pathology, and Welch in New York and I were probably the first two men in the country who tried it. I rather think Dr. Welch took the greater risk because he had not my agricultural resources, though a training and mental capacity far greater than mine.

For the next few years after his return from abroad in 1883 he engaged in various tasks, doing the autopsies at Bayview, teaching in the two local medical schools, helping John S. Billings prepare his National Medical Dictionary, writing articles for encyclopædias, and for a year serving as coroner's physician to the city. This position paid him three hundred dollars, but it "tied him down too much to places and dates" and

"being of a rather roving disposition" he "did not care to be at a certain place at a certain time," so he surrendered the job to another physician who had a greater political pull.

Meanwhile, in 1886 he had joined Welch and the early group of workers in the newly erected pathological laboratory which was to form part of a great hospital still in slow process of erection. And with the opening of the Johns Hopkins Hospital three years later there came another period as remarkable, he believed, as the first period, that of the opening of the University. To prepare himself for this event, in which he was slated to take part, he had gone abroad in 1888 for another year of study; and then for the two years prior to the establishment of the Medical School, in close intimacy—

There lived together in the hospital a group of men, all young, all very good fellows, all working very hard, and all having a very good time. It is an important thing that people should be happy in their work, and if work does not bring happiness there is something wrong; and both at the University and at the Hospital there was that wonderful happiness in work.

All others who shared in that cloistered, carefree, hard-working and stimulating life in the Johns Hopkins Hospital during those two early years have expressed themselves in similar vein, and there may never be anything quite like it again. Of this "mutual admiration society," as it was dubbed by visitors who had enjoyed its warm hospitality, the acting resident pathologist with the title of Associate Professor was one of the conspicuously unique figures. And it is natural that he should have been among the first of many to be called away by other institutions which were eager to capture something of the local spirit, hoping that it might prove transplantable.

Accustomed as a second-year student to the formal lectures then in vogue at the Harvard Medical School, the writer well remembers what an impression was made by the addition in 1892 to a somewhat austere faculty of this breezy informal pipe-smoking man, unmistakably sloping toward the sunny side, who was said to have been the first "outsider" ever appointed to a professorial chair in the School. Accustomed to work elbow to elbow with others, those of us who cared to do so

and knew enough to take advantage of the opportunity were welcome to a chair and a desk and a problem in his laboratory.

Indelible pictures of him must remain etched on the memory of all who had even casual contact with him in those early days in Boston when mayhap target practice was being held in the laboratory on a Sunday morning. He was a deadly shot for a thumbtack in a plank at twenty paces; and could swear at a golf ball as could few others. He was one of those rare people able without giving offense to punctuate quiet speech with oaths (even when talking to himself); and he depended upon and made considerable fuss over his occasional tipple preferably of Maryland rye. The growing up, later on, of his devoted children hampered him considerably in the first of these diversions —at least when at home; and what he thought of the Volstead Act and its necessary subterfuge does not bear repeating.

As can be seen from some of the quotations that have been given, he did not always necessarily expect to be taken seriously, particularly when in one of his pessimistic moods usually precipitated by examples of human selfishness he had happened to observe. But even these occasional outbursts had their amusing aspects, which would make him laugh (and swear) both at himself and the world. Someone has said that his attitude toward life and its varied experiences was more like that of Mark Twain than of anyone else he had ever known. And not to misjudge the lessening optimism and buoyancy of his later days, it may without impropriety be said that for sixteen years before his sudden end he had been victimized by increasingly severe attacks of angina pectoris.

But let us return again to the valedictory remarks of the retiring Professor of Pathological Anatomy on that December day of 1921, and we find him saying in conclusion:

It seems to me that the most important thing for the teacher is to awaken interest and enthusiasm in his students and to provide them with opportunities of following the interest which is aroused, for in this way we progress. Knowledge can not be given, it must grow and be slowly formed through one's own efforts. It is of no importance whatever to be talked to. I have always rather enjoyed lecturing, I like to talk, and I have gotten

I am sure more out of the lectures than any of my listeners, because a lecture is often an important discipline to the teacher. It enables him to classify things in his mind; through the lecture he often acquires new ideas. I know that sometimes as I have been lecturing I have seen an unscalable wall rising before the trend of my argument, and I have realized that if I said the next two or three sentences I would run against that wall, and one acquires a nimbleness of wit in finding a way around to the other side. I have enjoyed all that, and I think lecturing is an intellectual stimulus and comparatively harmless to the audience . . . it does not really very much matter what the lecturer says.

During those thirty years of consecutive teaching in a school which profited greatly by his ferment, he engaged in many time-consuming researches; and much as he loved to play, when once on a scientific quest he pursued it relentlessly and lived with his problem. While his independent papers deal with a large number of significant and timely subjects, he was more interested in fostering the work of his associates and pupils than in communicating the results of studies carried out by himself alone. Hence, the names of one or more collaborators appear on most of his major publications. Thus his early work on malaria (1885) was shared with A. C. Abbott; his monograph on amoebic dysentery (1891) with H. A. Lafleur; that on epidemic cerebrospinal meningitis (1898) with F. B. Mallory and J. H. Wright; the studies of 220 fatal cases of diphtheria (1900) with F. B. Mallory and R. M. Pearce; a syllabus of pathology for students (1904) with F. B. Mallory; and the several important studies on variola and vaccinia (1891–92) were subsequently brought together (1904) in a monograph under the names of his several coworkers, G. B. Magrath, W. R. Brinckerhoff, E. E. Tyzzer, E. E. Southard, R. L. Thompson, I. R. Bancroft, and G. N. Calkins.

Obviously what fostered the making of the larger number of these conjoint investigations was the opportunity, which contemporary epidemics afforded, of intensively studying the several diseases with which these papers deal; but at the same time sight was not lost of the opportunity for public service to the community in which the epidemics were causing alarm.

On the opening in 1913 of the Brigham Hospital to which he was appointed pathologist, the scope of his work was greatly enlarged though at the same time his responsibilities were doubled. The larger part of his time came to be passed in the hospital and the departmental protocols of the day are models in their thoroughness of detail. The lengthened number of hours he was obliged to spend in the microscopical study of dead tissues may possibly have served to accentuate—if anything could—his love of the outdoors and his interest in growing things.

Disturbed by the architecturally unadorned exterior of the new hospital, he personally selected, planted and during his odd hours cultivated the well chosen varieties of rambler roses that still surround it; and when so engaged, nothing gave him greater delight than for passers-by to mistake him for the official gardener. He had a gift for making things grow and was forever planting and tending shrubs and flowers somewhere. One of his chief joys was the Arnold Arboretum and his knowledge of every shrub and tree in that marvelous place was scarcely exceeded by that of his greatly admired friend, Charles S. Sargent, the Director. The horticultural interests now shown by certain members of the hospital staff of those days can probably be traced to the Sunday morning rambles in the Arboretum or elsewhere through the country in company with Councilman and Pasco, his devoted bulldog, who scarcely ever left his side.

By nature a close observer, this quality was further developed by the exercise of his profession and it was inevitable that he should look about him with greater keenness and more curiosity than most persons. Though a wide and discriminating reader, what he saw with his own eyes he questioned and interpreted in his own terms. He was, in its broad sense, a naturalist, and all things interested him. Two unusual opportunities came to him to gratify his fondness for travel and desire at first hand to study the unfamiliar flora of other regions. In 1916, he accompanied the Rice Expedition to the Amazon; and two years after his retirement at Harvard, having been invited temporarily to join the staff of the Pekin Union Medical College, he took

advantage of this to go around the world. He had a gift of description and was a most facile writer of highly entertaining letters which, usually undated, he would dash off on the sheets of ruled yellow paper which he kept ready at hand.

It might be supposed, by the unthinking, that those whose chosen occupation is the study of disease and death would in time become callous and indifferent to life. On the contrary, it is more apt to lead to an abhorrence of suffering of any kind and to a peculiar tenderness toward living things. In his difficult and often baffling search for the cause of disease by the examination of the dead body, by the microscopic study of the tissues and by the experimental reproduction of its processes in lower animals, the pathologist is laying the foundation on which its recognition, alleviation or possible cure by physician or surgeon during life is alone possible. It is a task requiring optimism, patience, intelligence and self-sacrifice of unusual degree. And to show what outlet a pathologist may have, this inadequate tribute to one of them may well close with an allusion to something else.

On relinquishing his chair and with it his hospital position, Councilman merely shifted his attention from the diseases of man to those of plants. One of his last printed papers, issued from the Arnold Arboretum, was the result of a microscopic study of the relation of the fungi of its essential humus to the root-system of *Epigæa repens.* As befitted its place of publication in the *Proceedings of the National Academy of Sciences,* it was a detailed presentation of a novel and little studied subject couched in scientific terms. But it was characteristic of him that he could not leave the trailing arbutus without unburdening himself in regard to its "fatal gift of conspicuous beauty" even though his feelings must be relegated to the footnote in which he says:

The Epigæa repens is one of the most beautiful and interesting of plants. Its blossoms which are among the earliest of the spring flowers are white or pink with a waxy texture and a delicious spicy odor and are borne at the extremities of the stems. The pale green hairy leaves and the pale pink or green stems streaming from the center close upon the surface of the

soil add to the attractiveness. The environment of dead brown leaves, mosses and low plants gives a perfect setting. It is unfortunate that these wonderful qualities should be those which are ensuring the destruction of the plant. Large quantities are gathered in the spring and hawked around the city streets, the unfortunate city dwellers seeking to satisfy atavistic and misunderstood yearnings for woods and green dales by purchasing the bunches. . . . The automobile by rendering remote places easily accessible has contributed greatly to its destruction, but the most powerful agency is the commercial exploitation which is ruthless and the traffic of great extent. Where the plants are abundant a family even selling them at wholesale can often earn $25.00 a day . . . but the plant is of slow growth and the relation of leaf and root is so finely adjusted that recovery after considerable loss does not take place and the stimulation to effect new growth cannot act on the plant and the fungus at the same time. By great care and skill plants can be transferred to other suitable localities and may even be propagated by seed but there is little prospect of its ever becoming a garden habitant. . . . I have known it to disappear completely from localities where formerly common and probably no plants can now be found within a dozen miles of any of the large cities. This desire to save the plant is not a mere matter of sentiment. No plant is more suitable for . . . the awakening in children through its study the all important wonder and curiosity. . . . Apparently like all wild beautiful things which man covets it must go but the loss of such things is a serious loss for man.

Thus Councilman went through life observing, studying, recording and speculating on things small and on things large, but always with consuming interest in the quest that engaged him and living up to his maxim that the chief happiness lies in work. When uprooted from his warm and fertile Maryland soil and transplanted to the rugged shores of Puritan New England, there must have clung to him some of the "essential native humus" which guaranteed more than a precarious foothold. Though "deeply engraved on his memory" was the bursting springtime of his boyhood home, he came to appreciate no less the beauties of a slower year's awakening. So it is suitable to leave him—engrossed in the study of the tiny Mayflower and vigorously championing its right to survive.

BIBLIOGRAPHY

1880

A Contribution to the study of inflammation as illustrated by induced keratitis. Prize essay of the Baltimore Academy of Medicine. Baltimore: J. Murphy & Co., 1880, 28 pp. Repr. from *J. Physiol., Lond.,* 1880-82, **3**, 76-87.

1882

Ueber hyaline Metamorphose des Miliartuberkels. *Med. Jahrb. Wien.,* 1882, 2 Ser., **12**, 51-56.

Tuberculosis as an infectious disease. *Maryland M.J.,* 1882-83, **9**, 289-294.

1883

The anatomical character of the tubercle. *Maryland M.J.,* 1882-83, **9**, 394-399.

The connection of the lower organisms with infectious diseases. *Arch. Med.,* 1883, **9**, 31-42.

A letter from Prague. [Dated July 16, 1883, signed "W.T.C."] *Med. News, Phila.,* 1883, **43**, 160-161.

1884

The microscopic investigation of the brain and spinal cord. *Am. Monthly Microscopical J.,* 1884, **5**, 201-203.

1885

A case of hypospadias simulating hermaphrodism: with specimens. *Maryland M.J.,* 1885, **12**, 174-175.

Report of two cases of tumor within the cranial cavity. *Maryland M.J.,* 1884-85, **12**, 331-333.

A contribution to the pathology of malarial fever. [With A. C. Abbott] *Am. J. M. Sc.,* 1885, n.s. **89**, 416-428.

Specimen showing congenital smallness of the right kidney with enormous compensating hypertrophy of the left kidney. *Maryland M.J.,* 1884-85, **12**, 462-463.

1886

Gunshot wound; diverticula of trachea and oesophagus. *Maryland M.J.,* 1885-86, **14**, 503.

Preliminary notes on the study of malarial blood. *Ibid.,* 1886, **15**, 441.

Certain elements found in the blood in cases of malarial fever. *Tr. Assn. Am. Physicians,* 1886, **1**, 89-97.

1887

Further observations on the blood in cases of malarial fever. *Med. News,* 1887, **50**, 59-63.

1888

The malarial germ of Laveran. *Am. Public Health Assn. Rep.*, 1888, **13**, 224-232.

Some further investigations on the malarial germ of Laveran. *Maryland M.J.*, 1887-88, **18**, 209-211. Also [Abst.] *Boston M. & S.J.*, 1888, **119**, 436.

An address on predisposition in tuberculosis. *New York M.J.*, 1888, **47**, 421-426.

Neuere Untersuchungen über Laverans Organismus der Malaria. *Fortsch. d. Med.*, 1888, **6**, 449-460; 500-507.

1890

Atypical epithelial growths. *Bull. Johns Hopkins Hosp.*, 1889-90, **1**, 20. [One column: report of meeting]

Primary tumor of pancreas. *Ibid.*, 51-52. [Report at meeting]

[John Shaw Billings—The National Medical Dictionary, etc. With the collaboration of *W.T.C. et al.* Phila., Lea Bros. & Co., 1890, 2 vols., 777, 779 pp.]

1891

Syphilis of the lung. *Bull. Johns Hopkins Hosp.*, 1891, **2**, 34-37.

Cirrhosis of the liver with glomerulo-nephritis. *Ibid.*, 40. [1½ column report]

Acute miliary tuberculosis. *Ibid.*, 84. [One column report]

The form of dysentery produced by the amoeba coli. *J. Am. M. Assn.*, 1891, **16**, 824-825. [Society report only]

Amoebic dysentery. [With H. A. Lafleur] *Johns Hopkins Hosp. Rep.*, 1891, **2**, 395-548.

1892

Discussion on the fibroid processes. *Tr. Cong. Am. Phy. & Surg.*, 1892, **2**, 147-151.

Dysentery. *Boston M. & S.J.*, 1892, **127**, 1-7.

Dysentery. *Tr. Assn. Am. Physicians, Phila.*, 1892, **7**, 113-140.

1893

Recent progress in pathology and bacteriology. *Boston M. & S.J.*, 1893, **128**, 188-192.

The pathological department of the Harvard Medical School. *Bull. Harv. M. School Assn.*, 1893, No. 4, 35-36.

The parasitic origin of carcinoma. *Boston M. & S.J.*, 1893, **128**, 392-395; 415-418.

A case of chronic nephritis in a cow. *Johns Hopkins Hosp. Rep.*, 1892-93, **3**, 215-221. Also: *Vet. J. & Ann. Comp. Path. Lond.*, 1894, **39**, 305-311.

Gonorrhoeal myocarditis. *Am. J. M. Sc.*, 1893, n.s. **106**, 277-285.

Sudden death due to the heart. *Boston M. & S.J.*, 1893, **129**, 457-462. Also: *Tr. Mass. Med.-Leg. Soc.*, 1888-1894, **2**, 133-147.

The pathology and diagnosis of diphtheria. *Am. J. M. Sc.*, 1893, n.s. **106**, 540-552.

The pathological anatomy of diphtheria and other pseudo-membranous affections of the throat. Presented at the Annual Meeting of the Massachusetts Medical Society, June 14, 1893. *Mass. Med. Soc. Communications*, 1893, **16**, 258-274.

1894

Gonorrhoeal myocarditis. *Med. & Surg. Rep. Boston City Hosp.*, 1894, 5.s., 55-68.

A case of multiple rupture of internal organs produced by a fall. *Boston M. & S.J.*, 1894, **130**, 109-111. Also: *Med. & Surg. Rep. Boston City Hosp.*, 5.s., 69-75.

Three cases of occlusion of the superior mesenteric artery. *Boston M. & S.J.*, 1894, **130**, 410-411.

A case of supposed syphilis of the heart. *Med. & Surg. Rep. Boston City Hosp.*, 1894, 5.s., 86-92.

Observations on the kidneys in a case of puerperal eclampsia. *Ibid.*, 93-99.

1895

The pathology of diphtheria. *Med. Communicat. Mass. M. Soc. Boston*, 1893-95, **16**, 721-736. Also: *Boston M. & S.J.*, 1895, **133**, 231-235.

Surgical pathology, including inflammation and the repair of wounds. Syst. Surg. (Dennis), *Phila.*, 1895, **1**, 145-238.

Infectious diseases, and the management of hospitals devoted to infectious diseases. *Med. & Surg. Rep. Boston City Hosp.*, 1895, 6.s., 279-294.

Osteomalacia. In: Twentieth Cent. Prac., N. Y., 1895, **3**, 233-249.

Recent progress in pathology. *Boston M. & S.J.*, 1895, **132**, 256-258; 282-284.

1896

A study of the lesions in selected autopsies. [With F. B. Mallory] *Med. & Surg. Rep. Boston City Hosp.*, 1896, 7s., 216-272.

An unusual action of the diphtheria bacillus. *J. Boston Soc. Med. Sc.*, 1896-97, **1**, No. 6, 3-6.

The results of some recent experiments on the cornea. *Ibid.*, No. 10, 1-7.

1897

Remarks on maternal impressions. *Boston M. & S.J.*, 1897, **136**, 32-34.

Epidemic cerebrospinal meningitis. *J. Boston Soc. Med. Sc.*, 1896-97, **1**, No. 13, 1-7.

An anatomical and bacteriological study of forty-nine cases of acute and subacute nephritis with special reference to the glomerular lesions. *Med. & Surg. Rep. Boston City Hosp.*, 1897, 8.s. 31-110.

Teratoma specimens. *Boston M. & S.J.*, 1897, **136**, 628-630.

A case of amoebic abscesses of the liver, with autopsy. [With J. C. Munro] *Med. & Surg. Rep. Boston City Hosp.*, 1897, 8.s., 352-358.

An anatomical and bacteriological study of acute diffuse nephritis. *Am. J. M. Sc.*, 1897, n.s., **114**, 23-44.

A case of double teratoma. [With R. W. Lovett] *J. Exper. M.*, 1897, **2**, 427-438.

1898

The relation of pathology to medicine. Annual Discourse, Massachusetts Medical Society, June 8, 1898. *Boston M. & S.J.*, 1898, **138**, 557-560; 581-584.

Epidemic cerebrospinal meningitis and its relation to other forms of meningitis. [With F. B. Mallory and J. H. Wright] A monograph published as a report of the State Board of Health of Massachusetts, Boston, 1898, 178 pp. *Cf.* also: *J. Boston Soc. Med. Sc.*, 1897-98, **2**, 53-57.

Epidemic cerebrospinal meningitis. [With F. B. Mallory & J. H. Wright] *Am. J. M. Sc.*, 1898, n.s. **115**, 251-270. *Cf.* also: *Phila. M.J.*, 1898, **1**, 937-946.

Acute interstitial nephritis. *J. Exper. M.*, 1898, **3**, 393-420. Also: *J. Boston Soc. Med. Sc.*, 1897-98, **2**, 189-192. Also: *Tr. Assn. Am. Physicians*, 1898, **13**, 300-325.

Cerebrospinal meningitis. *Boston M. & S.J.*, 1898, **138**, 145-148.

1899

The character of the cellular exudation in acute keratitis of the rabbit. *J. Boston Soc. Med. Sc.*, 1898-99, **3**, 99-116.

The growth and extension of carcinoma. *Boston M. & S.J.*, 1899, **141**, 256-259. Also: *Mass. Med. Soc. Communications*, 1899, **18**, 203-215.

Pathology Syllabus. [With F. B. Mallory] Copyright, 1899, 149 pp.

1900

The course in pathology at the Harvard Medical School. *Boston M. & S.J.*, 1900, **142**, 558-563.

Contributions to the science of medicine by the pupils of William H. Welch. *J. Am. M. Assn.*, 1900, **34**, 1493-94. [Editorial: anonymous]

Address at the 10th annual meeting of the Harvard Medical Alumni Association. *Boston M. & S.J.*, 1900, **143**, 38-42.

The relation of the pathological laboratory to hospital work. An address delivered at the opening of the Pathological Laboratory of the Rhode Island Hospital. *Providence M.J.*, July 1, 1900, **1**, 76-81.

The lobule of the lung and its relation to the lymphatics. *J. Boston Soc. Med. Sc.*, 1900, **4**, 165-168.

Pathology syllabus. [With F. B. Mallory] *Boston, J. L. Fairbanks & Co.*, 1900, 79 pp.

A study of the bacteriology and pathology of two hundred and twenty fatal cases of diphtheria. [With F. B. Mallory and R. M. Pearce] *J. Boston Soc. Med. Sc.*, 1900, **5**, 139-319.

1901

Opening remarks, first annual meeting of the American Association of Pathologists and Bacteriologists, Boston, April 5 & 6, 1901. *J. Med. Research,* 1901, **6** (n.s. 1), p. 2.

1902

Glanders. In: Reference Handbook of the Medical Sciences (A. H. Buck, Ed.), *New York: Wm. Wood & Co.,* 1902, **4**, 352-361.

Inflammation. *Ibid.,* **5**, 1-11.

Pathology Syllabus. [With F. B. Mallory] *Boston: J. L. Fairbanks & Co.,* 1902, 174 pp.

1903

Rhinoscleroma. In: Reference Handbook of the Medical Sciences (A. H. Buck, Ed.), *New York: Wm. Wood & Co.,* 1903, **6**, 971-973.

Tuberculosis. *Ibid.,* **7**, 886-901.

A preliminary communication on the etiology of variola. [With. G. B. Magrath and W. R. Brinckerhoff] *J. Med. Research,* 1903, **9**, 372-375.

The skin lesions in variola. *J. Am. M. Assn.,* 1903, **40**, 1393. [½ column Society report]

Address at memorial to Merrill Wyman, M.D. *Boston M. & S.J.,* 1903, **149**, 202-203.

1904

Studies on the pathology and on the aetiology of variola and of vaccinia. [With G. B. Magrath, W. R. Brinckerhoff, E. E. Tyzzer, E. E. Southard, R. L. Thompson, I. R. Bancroft and G. N. Calkins] *J. Med. Research,* 1904, **11**, 1-361. Introduction [With G. B. Magrath and W. R. Brickerhoff], pp. 1-11.

The pathological anatomy and histology of variola. [With G. B. Magrath and W. R. Brinckerhoff] *Ibid.,* 12-135.

Epicrisis. *Ibid.,* 345-361.

The modern conception and methods of medical science. *Boston M. & S.J.,* 1904, **151**, 425-433. Also: *American Medicine,* 1904, **8**, 718-724. Also: *Med. Rec.,* 1904, **66**, 555. [2-column report]

Pathology syllabus. [With F. B. Mallory] *Boston: J. L. Fairbanks & Co.,* 1904, 192 pp.

1905

The pathology and bacteriology of acute meningitis. *Albany M. Ann.,* 1905, **26**, 149-152. Also: *Tr. Med. Soc. New York,* 1905, 72-74.

Cerebrospinal meningitis. *Am. J. Pub. Hyg., Boston,* 1905, **15**, 344-356.

Some general considerations on the pathology of smallpox. *Am. Med.* 1905, **10**, 689-693. Also: *Am. Pub. Health Assn. Rep.,* 1905, Columbus, O., 1906, **31**, 218-229.

1906

The pathology of the kidney: some general considerations. *J. Am. M. Assn.,* 1906, **46**, 81-85.

Studies upon experimental variola and vaccinia in quadrumana, by W. R. Brinckerhoff and E. E. Tyzzer, with an introduction by W. T. C. *J. Med. Research,* 1905-06, **14**, 213-359. Introduction: 213-222.

1907

Changes in the lymphoid tissue in certain of the infectious diseases. *J. Am. M. Assn.,* 1907, **48**, 1073-1078. Also: *Harvey Lecture,* 1908, 268-286.

Smallpox. In: Modern Medicine (Osler), 1907, **2**, 250-300.

Chickenpox. *Ibid.,* 329-333.

Some general considerations regarding tumors. *Boston M. & S.J.,* 1907, **157**, 313-321.

1908

The etiological relationship of organisms found in the skin in exanthemata. [With G. N. Calkins] *Internat. Dermat. Cong. Tr.,* 1908, **1**, 260-266.

1909

The methods and the object of state examinations. *J. Am. M. Assn.,* 1909, **53**, 515-519.

The lesions of the skin and the tumor formations in xeroderma pigmentosum. [With G. B. Magrath] *J. Med. Research,* 1909, n.s. **16**, 331-355.

1910

The address at the commencement (on disease). *J. Alumni Assn., Coll. Phy. & Surg.,* Balt., 1910, **13**, 33-50.

A series of autopsy protocols from the records of the Department of Pathology of the Harvard Medical School, selected for the purpose of showing the lesions of the body produced in the more common diseases, the mode of production, and the inter-relation of these lesions—together with a table of weights of the body and of the organs at different ages. [With L. J. Rhea] [Without date or place: 236 pp., mimeographed.]

1911

A medical retrospect. *Yale M.J.,* 1910-11, **17**, 57-77.

Myatonia congenita: a report of a case with autopsy. [With C. H. Dunn] *Am. J. Dis. Child.,* 1911, **2**, 340-355.

1912

Experiences of a medical teacher. *Boston M. & S.J.,* 1912, **166**, 951-956.

Pathology, a manual for teachers and students. *Boston: W. M. Leonard, Pub.,* 1912, 405 pp.

1913

The nature of disease. *Calif. State J.M.,* 1913, **11**, 260-267.

Tumors. *St. Paul M.J.,* 1913, **15**, 317-333.

Disease and its causes. *N. York: H. Holt & Co.,* 1913, 254 pp.

Memorial meeting: Reginal Heber Fitz. [W.T.C. *et al.*] *Boston M. & S.J.,* 1913, **169**, 893-903. [Dr. Fitz's contribution to pathology, pp. 895-897.]

1914

The gliomatous tumors of the brain. *Long Island M.J.*, 1914, **8**, 401-409.

1915

Anatomical consideration of tumors of the brain with special reference to the gliomata. *Colorado Med.*, 1915, **12**, 289-301.

1916

Ochronosis and alkaptonuria. *Boston M. & S.J.*, 1916, **174**, 658. [One-column report]

Further reflections of a medical teacher. *J. Am. M. Assn.*, 1916, **66**, 2045-2051. Also: *Bull. Med. & Chir. Fac. Maryland*, 1916-17, **9**, 52-66.

1918

The medical report of the Rice expedition to Brazil. [With R. A. Lambert] *Cambridge: Harv. Univ. Press*, 1918, 126 pp.

Charles Sedgwick Minot (1852-1914). *Proc. Am. Acad. Arts & Sc.*, 1918, **53**, 840-847.

Friedrich Daniel von Recklinghausen (1833-1910). *Ibid.*, 872-875.

1919

Some of the early medical work of Sir William Osler. *Bull. Johns Hopkins Hosp.*, 1919, **30**, 193-197.

The conditions presented in the heart and kidneys of old people. In: Contrib. Med. & Biol. Research . . . . Sir W. Osler. *New York: Paul B. Hoeber*, 1919, **2**, 918-928.

1920

Osler in the early days at the Johns Hopkins Hospital. *Boston M. & S.J.*, 1920, **182**, 341-345.

1921

A lecture delivered to the second-year class of the Harvard Medical School at the conclusion of the course in Pathology, Dec. 19, 1921. [Last lecture as a teacher of undergraduates in medicine] Privately printed, 23 pp.

1922

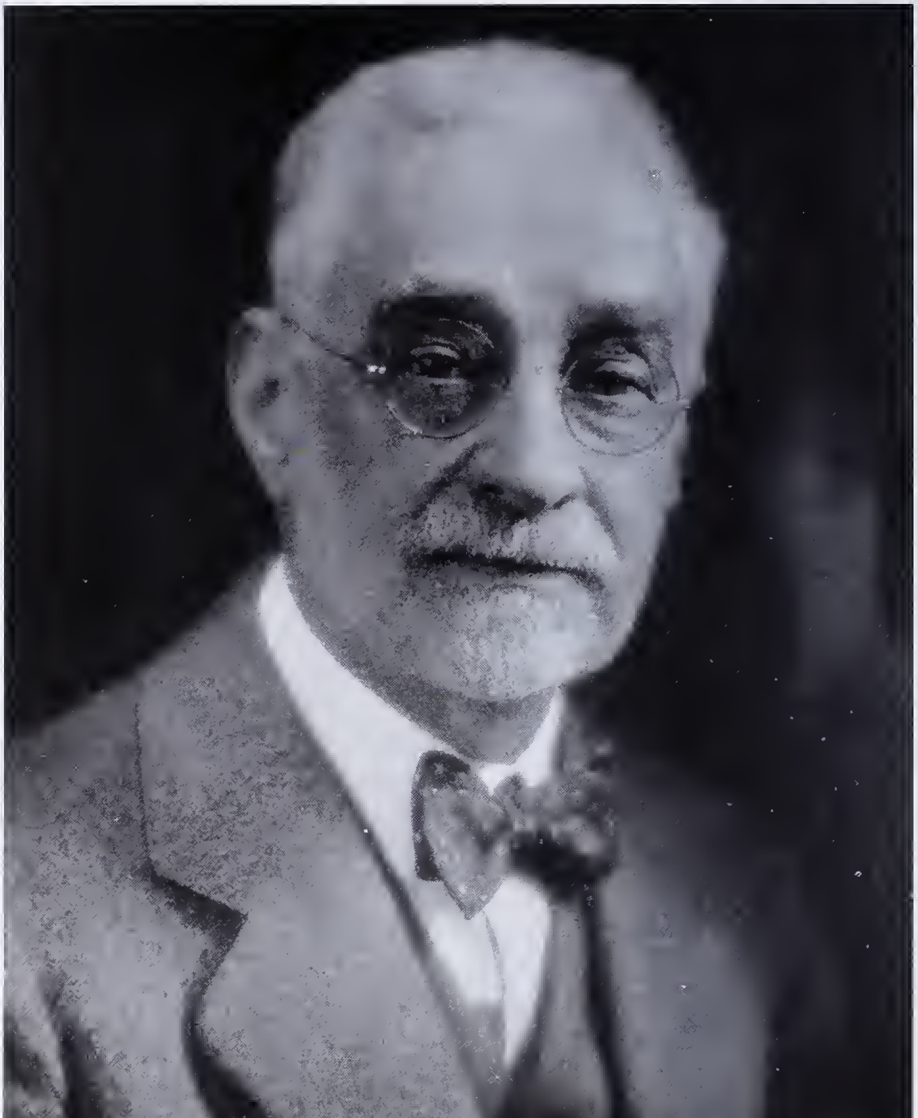
Plague-like infections in rodents; summarized report. [With R. P. Strong] *Tr. Assn. Am. Physicians*, 1921, **36**, 135-143.

1923

The root system of epigæa repens and its relation to the fungi of the humus. *Proc. Nat. Acad. Sc.*, 1923, **9**, 279-285.

1924

The relation between the roots of plants and fungi. *Proc. Soc. Exper. Biol. & Med.*, 1923-24, **21**, 361-363.



William L. Elkin

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OF

WILLIAM LEWIS ELKIN

1855–1933

BY

FRANK SCHLESINGER

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William Lewis Elkin was born in New Orleans on the 29th of April, 1855. His father, Lewis Elkin (1815-1867), was a teacher and had kept a private school, but at the time of William's birth he was Inspector of Public Schools for the city. Shortly afterwards he went into the business of manufacturing carpets and this proved to be an unusually successful venture. William's mother, Jane (1826-1890), was the daughter of the Reverend John Fitch of Thetford, Vermont. (The name of this village of only a few hundred dwellers is already well known to astronomers as the birthplace in 1838 of S. W. Burnham, the great observer of double stars.) Jane Fitch came to New Orleans with her mother when a young girl, and there she was married to Lewis Elkin in 1846. Five children were born to them of whom William was the third and the only one to reach maturity, the four others having died in infancy.

In 1867 Lewis Elkin was appointed Commissioner for the State of Louisiana at the Paris Exposition. He was preparing to go abroad with his wife and his son when he suddenly fell ill and died within a few days. Close friends who were going to Europe prevailed upon Mrs. Elkin not to change her plans, and accordingly she and William left America for what they thought would be a matter of a few months. She did not return till seventeen years later, and William in this long interval made only two short visits to America. They lived in one country after another in Europe never remaining very long in any one. As a result William's early education was to say the least unusual in its variety. One consequence was to give him exceptional facility in modern languages. He spoke and wrote German and French as well as he did English, and could get along in Italian and Spanish. He also acquired a love and a wide knowledge of the music of all nations, and this afforded him a never-failing source of deep pleasure throughout his life.

In 1870, while they were in Switzerland, the boy (then fifteen years old) had a severe illness, probably dysentery. In after life he used to say that perhaps he never quite recovered from this attack. At any rate during most of the years to follow he was seldom in perfect health, and he was able to accomplish what he did only because of a careful husbanding of his energies, and as a consequence of the watchful care that first his mother and then his wife bestowed upon him.

In 1872 Elkin decided to become a civil engineer and entered the Royal Polytechnic School at Stuttgart in Germany, where he was graduated C.E. in 1876. In the meantime, however, he had acquired a liking for astronomy and decided to take it up as his life work. To this end he spent four years at Strassburg Observatory, then an astronomical center chiefly because of Winnecke, the director, who had the reputation of being the best teacher of astronomy of his time. Five other students who later made their mark in astronomy were at Strassburg with Elkin. They were Julius Bauschinger, who eventually (1909) succeeded Winnecke, and who after 1918, when Strassburg once more became Strasbourg, was appointed director of the observatory at Leipzig, surviving Elkin by only a few months; Karl Friedrich Küstner, discoverer of the variation of latitude, director of the Bonn Observatory; Ernst Hartwig, director of the Hamburg Observatory; Hermann Struve, director of the Berlin Observatory; and Friedrich Ambronn, Professor at Göttingen. Of these six notables the last survivor was Küstner, who died in 1936.

Elkin was graduated Ph.D. at Strassburg in 1880, his dissertation being on "The Parallax of Alpha Centauri." This is a discussion of all the information then available on this interesting system. The material is handled with admirable completeness and judgment, and the paper exhibits the same sterling qualities that Elkin's later work showed in such marked degree.

About a year before Elkin left Strassburg occurred one of those apparently trivial events that so often change the course of a career. This was a visit to Strassburg by David Gill, just appointed director of the Cape Observatory. Gill and Elkin

had both used the heliometer, and both had great confidence in its possibilities. This form of instrument afforded by all odds the most accurate method for measuring large arcs in the sky, and until the introduction of photography presented the only feasible method, though a very laborious one, for attacking the delicate problem of measuring stellar parallaxes. Gill and Elkin spent perhaps half an hour together during this visit at Strassburg. In those few minutes the two men conceived a deep admiration for each other, and laid the foundation for a friendship that played an important part in both their lives, a friendship that lasted till Gill's death thirty-five years later. In that half hour they found time to discuss the future of the heliometer. And most astonishing of all, Gill then and there extended to Elkin, who accepted without hesitation, an invitation to come to Cape Town and to stay there as his house guest for a term of years.

In December 1880, Elkin sailed for South Africa and arrived there early in 1881. A few months later we find Gill writing as follows to Elkin's mother, who was then at Stuttgart: "I had hoped to make your acquaintance when I was in Europe . . . for it seems a pity that I should not know the mother of my friend and companion. . . . Now, about your son: he is a fine fellow, just the man I took him for after my first half hour's conversation with him. He has true astronomical talent, enthusiasm and patience, and I believe will live to be an honour to you and his country. Personally my wife and I are much attached to him—his disposition is so lively and so gentle—his consideration for others' comfort so great that it is quite a pleasure on social grounds alone to have him with us—and he has quite won our hearts. My wife and I make a very Darby and Joan couple—we feared that any one living in our family circle would make some difference and affect our simple home life. We do not find this at all with your son; he understands our ways, and I hope and think he is comfortable. I think too I can honestly say he is looking stronger than when he came out, and you may keep your mind quite easy

about his welfare, till he has completed the important work which brought him here."

Elkin remained at the Cape for three years. In that time he and Gill made a weighty contribution to our knowledge of stellar distances. They measured with the utmost care the distances of nine first-magnitude stars. These were important in themselves, for accurate parallaxes were very rare indeed in the eighties. But still more important was the estimate they enabled the authors to make concerning what a serious attack on stellar parallaxes with the heliometer would be likely to yield with respect to quality and quantity. They concluded that a diligent observer could produce about sixteen parallaxes per annum, each with a probable error of 0".020.

With the exception of the two heliometers at the Cape all other instruments of this type were at that time to be found in Europe, but when Yale Observatory was reorganized in 1881, chiefly through the efforts of H. A. Newton, the plans included a large heliometer that should be as perfect as it was possible to make it. Such an instrument was made by the Repsolds and was installed at New Haven in 1882. It still remains the only heliometer in the western hemisphere. As was very natural, Elkin was offered an appointment as "Astronomer in Charge of the Heliometer" at Yale. He accepted this office and moved to New Haven with his mother in 1884, remaining there until his death half a century later.

Let us stop for a moment to glance at the condition of American astronomy fifty years ago. This country had by no means attained then the position it now occupies. First of all, the facilities for training students in the sciences were far behind those abroad, as was only natural in a young country that had been chiefly occupied in establishing itself politically and economically. I believe I am right in stating that B. A. Gould (1824-1896) was the only American astronomer older than Elkin who received his training abroad, or indeed whose explicit training, wherever acquired, approximated in character and in thoroughness that represented by the degree Ph.D. Newcomb, Hill, Hall, Pickering, Newton, Langley, Chandler and others

of their stature and their time were all largely self-taught. In that day our great observatories, Lick, Yerkes and Mt. Wilson, were still in the future. In Canada, too, where three great institutions of this kind have since sprung up, there was then no observatory worthy of the name. Gould, after a stormy time at Albany, had gone to South America to establish what was to become the National Observatory of Argentina. Barnard was still at Nashville, discovering an astonishing number of comets. Burnham was at Chicago discovering an equally astonishing number of close double-stars with a small telescope. Pickering had recently come to Harvard and was beginning to make his colleagues a little uncomfortable by the revolutionary character of his work, measuring the brightness of every star he could reach and ascertaining the character of its spectrum. Newcomb and Hill at Washington and Newton at New Haven were devoting their energies to Celestial Mechanics and in that field winning the admiration of their colleagues the world over. Thus, while there was no lack of astronomical activity, the country was far behind in one of its most important branches, the one that includes the problems that depend for their solution upon the precise measurement of the places of stars and other objects, or as we should now word it, upon astrometry.

This was peculiarly Elkin's field, by choice, by training, by opportunity and by performance. Speaking at a meeting in Boston in 1896, Dr. Seth C. Chandler, editor of the *Astronomical Journal* and one of the country's leading astronomers, took this occasion to pay a tribute to Elkin's work. He coupled his name with that of George William Hill, and said:

"The work of each is of the very highest of its type. Both names belong to that small and most select class which any discriminative critic must include in an account of the contributions of the highest class made by Americans to the astronomy of the nineteenth century. Yet the works of both partake, each in its way, of that purely technical character which makes a descriptive analysis of them, for the purpose of securing for them an adequate and intelligent popular appreciation, a difficult task. It is for this reason that work like Dr. Elkin's so little appears in popular books, magazine and newspaper articles.

It contains no theatrical or sensational element. It requires painstaking study on the part of the writer and patient attention on that of the reader."

For his first work with the Yale Heliometer, Elkin decided to determine the relative places of sixty-nine stars in the Pleiades Cluster. This gave him an opportunity to test the heliometer in the measurement of long arcs, up to 6000″. The stars were first referred to Alcyone and then to each of four fairly bright stars removed from the center of the cluster. This constitutes a laborious piece of observing, involving the measurement of some 1400 position-angles and distances. The measures, reduced with all possible rigor, yielded relative places for these 69 stars that remained the standard for many years. By comparing them with the measures made by Bessel nearly fifty years earlier Elkin was enabled to derive the proper motions of 51 of them, and to say definitely which stars really belonged to the cluster and which were merely projected on that region of the sky.

Elkin next made a similar triangulation of the stars near the North Pole of the heavens. At his suggestion similar triangulations were made by other members of the staff of the cluster in Coma Berenices and, for the second time, of the Pleiades.

The work that Gill and Elkin had carried out on the parallaxes of southern first-magnitude stars, was next extended by Elkin to the ten northern first-magnitude objects. They confirmed the general result that these objects are in general not among our nearest neighbors in space and they indicated that large proper motion rather than brightness is a good indication of closeness. Elkin then set on foot and carried out with the co-operation of his assistants, Frederick L. Chase and Mason Smith, a comprehensive parallax survey of stars of large proper motion. Some of these stars were observed often enough to yield parallaxes with probable errors averaging 0″.015. Others were observed on only twelve to sixteen nights, and for them parallaxes were obtained with probable errors averaging about 0″.03; this would now not be considered a high degree of precision, but they were excellent for that day. Altogether 238

parallaxes were determined with the Yale Heliometer. These results constitute by far the most important single contribution to our knowledge of stellar distances up to that time. The writer had occasion to examine these parallaxes critically in 1923 in the course of the preparation of a general catalogue of parallaxes. He found that they were nearly free from systematic error, and that the probable errors assigned by the authors were on the whole very near the true probable errors, a somewhat unusual quality in any series, early or recent.

Beginning in 1888 Elkin once more collaborated with his friend Gill in an important undertaking. Some years earlier, Gill had made a determination of the solar parallax by observing Mars and from the parallax of the latter deducing that of the sun by applying the factor indicated by Kepler's laws. This work was carried out by means of a small heliometer, inferior in several respects to the improved and larger heliometers which could be procured some years later; and so, although the resulting value of the solar parallax was not one of high precision, it indicated the possibilities of the method. In 1888, then, with heliometers of the highest type available at the Cape and New Haven, Gill proposed to Elkin that they should make a new attack on this problem, with the important modification that not Mars but several selected asteroids be observed. Mars presents too large a disc to permit accurate bisection, while the asteroids are ideal in this respect. Elkin accepted this invitation with much enthusiasm and for several years he and Gill and their assistants observed the selected asteroids (Victoria, Sappho and Iris) on every suitable occasion. The results appear in Volumes VI and VII of the Cape Annals. They led to $8\overset{''}{.}802$ for the solar parallax with a probable error of only $0\overset{''}{.}005$. This is a great improvement over any determination that preceded it. Perhaps even more valuable than the parallax itself are the by-products of this research: the mass of the moon, the constants of nutation and aberration, the dynamic flattening of the earth, and the lunar equation.

Any one who has had to derive the proper motions of stars from their recorded positions in star-catalogues knows how

laborious an undertaking this is. For even a single object this task may easily consume the best part of a week. It is first necessary to examine scores of catalogues to see which ones contain the star in question and this is rendered difficult by the multiplicity of "equinoxes" to which these various catalogues are referred, making it necessary to compute the precession for each date. For catalogues published before 1900 at least twenty-six different equinoxes have been used. To lighten this work for astronomers, Elkin with admirable public spirit organized an ambitious project and carried it through with very meager assistance. He bound up with appropriate interleaves a complete four-volume set of the Bonn Durchmusterung, and upon these interleaves he indicated what stars appear in every available catalogue. Altogether 175 catalogues were examined in this laborious way and more than 900,000 star positions were indexed. With characteristic thoroughness the whole of the work was repeated independently and the entries made in a second similarly bound set of the Durchmusterung; the two sets were then compared. This Yale Index has played an important part in this branch of astronomy; many astronomers have made use of it and have profited by Elkin's foresight. The Index has recently been partly superseded by the Geschichte des Fixsternhimmels which not only indexes these star positions but actually reprints them reduced to a single equinox; up to the present time, the first 22 hours of right ascension have been published for stars north of the equator. For stars between the equator and declination 23° south the Yale Index continues to be as useful as ever.

There has been at Yale a tradition concerning the observation of meteors that goes back to the early years of the nineteenth century. Olmsted, Twining, Loomis and Newton have all contributed to this subject. Elkin was to continue this tradition. He began experimenting in the early nineties on the photography of meteors and he was so encouraged by these preliminary trials that he applied for a grant of $2,000 (a substantial one in those days) from the J. Lawrence Smith Fund of the National Academy of Sciences, for the construction of an instru-

ment especially designed for this work. The grant was made and the instrument installed on the observatory grounds in 1894. This consists of a long clock-driven polar axis to which any number of cameras could be attached. By mounting six of them at appropriate angles with respect to each other a large area of the sky was covered. The plates record the trails that correspond to their rapid flight across the sky. In order to record their angular velocities a wheel having an opaque sector and revolving at a known rapid rate was mounted so as to interrupt the exposures periodically and so the trails on the plate are series of dashes with short spaces between. In order to get the parallaxes of the meteors a similar but somewhat smaller instrument was set up at Hamden three kilometers to the north of the observatory, and the two sets of cameras were pointed to about the same part of the sky. (This supplementary station was later moved to Whitneyville, also several kilometers to the north of the observatory at New Haven.)

In the course of about fifteen years observing a fair number of meteors were recorded in this ingenious way. But on the whole this number was a good deal smaller than the preliminary experiments had led Elkin to expect, and this was a source of disappointment to him. However, the results actually obtained are of high value. Elkin has published a number of brief papers on this subject. No complete account has as yet appeared, but I am glad to be able to state that such an account is in press, through the kindness and under the editorship of a leading authority in this field.

H. A. Newton had been director of Yale Observatory from 1882 to 1884; during the following twelve years he continued to direct the scientific policies of the institution without stipend, as Secretary of the Board of Managers. The directorship remained vacant for twelve years until Elkin was appointed to it in June 1896, a few weeks before Newton's death.

During the first fifteen years or so of his connection with the observatory, Elkin made an astonishing number of observations for a man whose health was never robust, and with an instrument that is notoriously difficult to manipulate. A modern

heliometer has eight handles that must be operated with the arms held constantly above the head. In the late nineties, however, his health no longer permitted him to observe so steadily and thereafter, much to his regret, he observed only intermittently as circumstances permitted. His time and energy were of course well accounted for by administrative duties and with that large part of the work of the observatory that called for pencil and paper. But Elkin was one of those who maintained that the first duty of an observer is to observe, and his inability to carry out this policy to the letter troubled him not a little. As a result of this feeling he engaged an additional young assistant, trained him to observe with the heliometer, and for a long term of years paid his stipend out of his own pocket. But even this expedient satisfied him only temporarily and in 1910, when he was in his fifty-fifth year, he resigned his directorship. He was then eligible for a retiring allowance from the Carnegie Foundation, but he refused to accept one. He had sufficient means, he said, to satisfy the simple needs of his wife and himself, and he would not wish to deprive some other individual, less fortunately situated in this respect, of the benefits of the Carnegie Foundation. It has been authoritatively stated that this is the only instance in the history of the Carnegie Foundation of the refusal of a pension.

After his retirement Elkin's astronomical work ceased. He was able to keep up his reading in the science and follow newer developments like star streaming, galactic rotation and relativity. But his health did not permit him to indulge in a thorough study of any of these aspects of the science. Even to talk over these matters with former colleagues seemed to distress him, because he never lost his deep enthusiasm for the subject and such discussions soon threw him into a slight fever of excitement. His friends learned to know this and to avoid leading the conversation into these channels.

But he had many other interests that made his later years very full ones. Chief among these was his love of music. He was himself an excellent performer on the piano, often delighting his family and his friends with his improvisations. He lost

few opportunities to hear good music, and though he denied that he was a performer he did admit that he was an expert listener. Color photography, too, claimed his enthusiasm for some years, when the Lumière process was new. Throughout his life he was a careful reader of solid literature in several languages. In his day he had played a good deal of chess and whist (the old-fashioned whist and none of its modern descendants) but in later life he found these too fatiguing and turned to cribbage, vingt-et-un and solitaire. It amused him to keep accurate scores of these games and thus to establish their statistics. He was an expert motorist, understanding the car in all its mechanical details; this knowledge he delighted to place at the disposal of his friends and neighbors who availed themselves freely of it in a day when troubles of this kind were much more frequent than they are now.

One of Elkin's most striking characteristics was the accuracy of his memory and of his statements. This showed in his scientific work as well as in his every-day intercourse. If he was not sure of a thing, he remained silent about it; but if he made any statement concerning it one could rely implicitly upon its being well-founded. A life-long friend writes:

> "That accurate memory, flashing out in fields which should have been more mine than his! But if I was humbled, it was never because he humbled me. His offhand acquaintance with all sorts of subjects was so surprising as to be humorous."

When he withdrew from astronomy in 1910, he was convinced that his life was near its close, but he lived twenty-two years to enjoy his retirement. His wife devoted herself to his care and allowed nothing, however important, to interfere with this first consideration. When the end finally came, on May 30, 1933, it came quickly and without suffering.

He is survived by his widow, the former Catharine Adams of New Haven, to whom he was married in 1896. No children blessed this otherwise ideally happy union.

A number of distinguished honors came to Elkin unusually early in life. At the age of thirty-seven he was elected a Foreign

Associate of the Royal Astronomical Society of London, this honor being limited to fifty astronomers at any one time; at his death he was by seven years the senior associate in order of election. He was chosen a member of the National Academy of Sciences at the age of forty when the membership was limited to one hundred. Among other honors were the Lalande Medal of the French Academy and an honorary doctorate from the University of Christiana.

BIBLIOGRAPHY OF WILLIAM LEWIS ELKIN

Ueber die Bahn des Cometen V 1854. Astronomische Nachrichten, Vol. 94, pp. 73-80, 1879.

Parallaxe von α Centauri. (Dissertation), Karlsruhe, 1880.

Mittheilung nach einem Schreiben, betreffend den Grossen Cometen *b*. 1881. Astronomische Nachrichten, Vol. 100, pp. 93-94, 1881.

(with W. H. Finlay.) Elements of the Great Comet (*b*) 1882. Monthly Notices, Royal Astron. Soc., Vol. 43, pp. 24-25, 1882.

Observations of the Great Comet (*b*) 1882. Monthly Notices, Royal Astron. Soc., Vol. 43, pp. 22-24, 1882.

Note on the Orbit of the Great Comet, 1882 II. Astronomische Nachrichten, Vol. 104, pp. 281-282, 1883.

Telegraphic Determination of the Longitude of Kimberley. Trans., South African Philosophical Soc., Vol. 3, p. 26, 1883.

The Polarizing Photometer and its Application to α Centauri. Trans., South African Philosophical Soc., Vol. 3, pp. 29-30, 1883.

(with David Gill.) Heliometer Determinations of Stellar Parallax in the Southern Hemisphere. Memoirs, Royal Astron. Soc., Vol. 48, pp. 1-194, 1884.

Great Comet, 1882 II. Observations with the Heliometer. Annals, Royal Observatory, Cape of Good Hope. Vol. II, pt. I, pp. 19-25, 1885.

Determination of the Relative Positions of the Principal Stars in the Group of the Pleiades. Trans., Astron. Observ. Yale Univ., Vol. I, pt. 1, 1887.

Mean Parallax of First Magnitude Stars. Sidereal Messenger, Vol. 7, pp. 395-397, 1888.

Comparison of Dr. Gould's Reductions of Mr. Rutherfurd's Pleiades Photographs with the Heliometer Results. Astron. Journ., Vol. 9, pp. 33-35, 1889.

On the Relative Refrangibility of the Light of Mars and Stars. Astron. Journ., Vol. 10, pp. 97-98, 1890.

Rutherfurd Photographic Measures of the Pleiades. Pub., Astron. Soc. Pac., Vol. 4, pp. 134-138, 1892.

Triangulation of Stars in the Vicinity of the North Pole. Trans., Astron. Observ. Yale Univ., Vol. I, pt. 3, 1893.

Photography of Meteors. Astron. Journ., Vol. 13, p. 132, 1893.

Instrument for the Photography of Meteors for the Yale Observatory. Pop. Astron., Vol. 2, pp. 17-18, 1894; Astron. and Astrophys., Vol. 13, pp. 626-627, 1894.

(with David Gill and Arthur Auwers.) A Determination of the Solar Parallax and Mass of the Moon from Heliometer Observations of the Minor Planets Iris, Victoria, and Sappho made in the Years 1888-1889 at the Royal Observatory, Cape of Good Hope. Annals, Royal Observ., Cape of Good Hope, Volumes 6-7, 1896-97.

Observations of the 1898 Leonid Meteors and Discovery of a Comet at the Yale Observatory. Astron. Journ., Vol. 19, pp. 151-152, 1898.

Photographic Observations of the Leonids at the Yale Observatory. Astrophys. Journ., Vol. 9, pp. 20-22, 1899.

Results of the Photographic Observations of the Leonids, 1898, at the Yale Observatory. Astrophys. Journ., Vol. 10, pp. 25-28, 1899.

The Velocity of Meteors from Photographs. Astron. Journ., Vol. 20, p. 102, 1899.

The Velocity of Meteors as deduced from Photographs at the Yale Observatory. Astrophys. Journ., Vol. 12, pp. 4-7, 1900.

Determination of the Parallax of the Ten First Magnitude Stars in the Northern Hemisphere. Trans., Astron. Observ. Yale Univ., Vol. I, pt. 4, 1902.

Todes-Anzeige Josiah Willard Gibbs. Astronomische Nachrichten, Vol. 162, No. 3877, 1903.

The Yale Heliometer Measures of the Vulpecula Zone. Astronomische Nachrichten, Vol. 163, No. 3896, pp. 117-120, 1903.

Revision of the First Yale Triangulation of the Principal Stars in the Group of the Pleiades. Trans., Astron. Observ. Yale Univ., Vol. I, pt. 7, 1904.

(with Frederick L. Chase and Mason F. Smith.) Parallax Investigations on 163 Stars Mainly of Large Proper Motion. Trans., Astron. Observ. Yale Univ., Vol. 2, pt. I, 1906.

(with Frederick L. Chase and Mason F. Smith.) Parallax Investigations on 35 Selected Stars. Trans., Astron. Observ. Yale Univ., Vol. 2, pt. 2, 1910.

(with Frederick L. Chase and Mason F. Smith.) Catalogue of Yale Parallax Results. Trans., Astron. Observ. Yale Univ., Vol. 2, pp. 385-400, 1912.

Geo. Davidson

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OF

GEORGE DAVIDSON

1825–1911

BY

CHARLES B. DAVENPORT

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George Davidson was born at Nottingham, England, May 9, 1825. He was of Scottish descent, his father, Thomas Davidson, Sr., having been born 1792 in Arbroath on the rocky east coast of Scotland, and his mother Janet Drummond at Montrose on the same coast about thirty miles north. The Drummond family had warehouses in Montrose and supplied the British with sail cloth during the Napoleonic wars. Of such maritime ancestry, it was appropriate that George became a geographer of the Pacific coast of the United States and Alaska and his younger brother, Thomas Davidson, Jr., (b. 1828) a naval constructor with high rank in the U. S. Navy, who built the "Tuscarora" used by Admiral Belnap in his Pacific deep-sea soundings.

Thomas Davidson, Sr., was not very prosperous even in England and so migrated with his family to Philadelphia in 1832. The sons received the rudiments of education from their mother and George graduated from the Central High School at Philadelphia in 1845 with the highest honors of his class.

From the beginning of his high school course Davidson had been in contact with Alexander Dallas Bache who had left the army to become (1836) President of Girard College, then in course of erection. But before it opened he was elected (1838) principal of the Central High School. In November, 1842, Bache employed Davidson and one or two others to serve as observers at the Girard College Magnetic Observatory to watch for meteors. When in 1842 Bache resumed his former professorship in physics at the University of Pennsylvania, Davidson made large drawings for his lectures, working daily at Bache's home from 3 p. m. to 8 or 9 p. m. He then observed from 12:30 to 8:30 a. m. But such strenuous activity combined with his high school work could not last long and he was afterwards

placed on evening duty with general direction over night work, being responsible for the discipline and accuracy of the observers. As soon as Davidson graduated, Bache appointed him on his field party in the Coast Survey to which Bache had been appointed eighteen months previously. Davidson was now in almost hourly contact with Bache, always recording for him in his daily hours of observation.

At the end of 1845 Davidson went into the field as observer; during the winter in the South, during the summer with Bache's field party. In 1849 Bache suggested to Davidson that he be transferred to California. Davidson declined unless promoted. In May, 1850, the desired promotion was made.

Upon the acquisition by the United States of the Pacific slope in 1848, following the Mexican War, the necessity for more accurate charts of the coast was recognized and Alexander Dallas Bache in October, 1848, ordered a hydrographic survey to be made by a party in charge of Lieut. W. P. McArthur of the Navy. A reconnaissance was made before McArthur's death in December, 1850, and charts were published at the end of that year. At about the same time Commander Cadwalader Ringgold of the U. S. Navy undertook a survey of San Francisco Bay and the Sacramento River and his charts were printed in 1851. A more intensive and accurate survey of the coast was needed, and in 1850 Davidson was sent by Bache with three associates to do geographical and astronomical work while Lieut. James Alden conducted the hydrographic work. Davidson's first work was the determination of the correct position of Point Conception, the most prominent and dangerous angle on the western coast of the United States. He determined longitude, variation and dip of the magnetic needle by moon culminations and from the observed time of occultations of the stars by the moon. The longitudes of the minor stations were determined by the transportation of chronometers. At that time telegraphic methods were not available. He reported upon the best location for the proposed lighthouses in the neighborhood.

During the first four years other stations were occupied in succession at Monterey, San Diego, Cape Disappointment near

the mouth of the Columbia River, Port Orford, and Neah Bay, near the entrance to Puget Sound. Campbell, 1914, writes:

"Coastwise travel in those days was largely by sailing vessels, and surf landings were unavoidable at many stations on the capes and points. There were occasionally personal risks from hostile natives, as at Neah Bay, where the observations were made from behind breastworks with men and guns constantly ready to repel attack."

The necessity of checking his longitude determinations led Davidson to observe for times of contact the partial solar eclipse of May 26, 1854, at Humboldt Bay, of March 25, 1857, at San Francisco; of July 18, 1860 at Sonoma Mountain. Occultations were also observed in the Pleiades in 1857 and 1860.

After main points had been carefully located astronomically, triangulation followed, as in the survey of Puget Sound, Admiralty Inlet and the northern sheet of the west coast of the United States.

Probably in consequence of his almost superhuman activity along the coast in all sorts of bad weather combined with surf wading and exposure in unsheltered spots, Davidson became very ill in the spring of 1857 and was hospitalized in San Francisco. In the early summer he took up his trigonometric survey again and again fell ill and was under treatment for a month. Finally, in October he started back to the east and reported at Washington. At headquarters Davidson brought to completion his "Directory of the Pacific Coast," which was invaluable to mariners and for long, in its various editions, the standard of reference.

On October 5, 1858, Davidson married at Whitepost, Virginia, Ellinor Fauntleroy, the daughter of Robert H. Fauntleroy, a friend and associate on the Coast Survey, designated by Bache "one of the most meritorious officers of the Survey who lost his life in the service." Davidson had indeed named the brig that he used in the Survey the "R. H. Fauntleroy." Robert H. Fauntleroy had married Jane Dale Owen whose brothers David Dale and Richard Owen were leading geologists, while their brother Robert Dale Owen was, like his Scottish

father, Robert Owen, a social reformer and leader in the New Harmony (Indiana) communistic experiment. Later he was elected to Congress, forced the settlement of the Oregon boundary dispute, fathered the bill to establish the Smithsonian Institution and before the outbreak of the Civil War was a leading abolitionist. Davidson and his wife had four children, a daughter, Ellinor C., and three sons of whom one, the first, George Robert, was a precocious child who died young from a fall. The brilliant second son, George Fauntleroy (Harvard '85) died in 1900 aged 38, while the third, Thomas D., was a lawyer and, like his father, an inventor. Davidson's wife was a gracious hostess to the constant stream of visitors who were attracted by his vivid and magnetic personality and her "calm and controlled nature developed a mind unusually impartial and disinterested, so that her opinions were sought and valued." Doubtless these qualities and her charming humor and strong social instincts were helpful to her husband.

With his bride Davidson returned to San Francisco November 14, 1858, and took up the primary and secondary triangulation north of San Francisco and the astronomical observations upon which they were based. In 1860 Davidson while at Ross Mountain setting up a signal pole was severely injured and compelled to return to San Francisco. In December, 1860, he was ordered to Washington; and here he reentered into most confidential relations with his chief.

In December, 1860, the nation was on the verge of war. Davidson was assigned to a survey of the Delaware River for its defense; in 1862 he was placed in charge of the armed Coast Survey steamer "Vixen" and sent to Florida; in 1863 he was appointed Engineer of Fortification for the defense of Philadelphia on the north, and made a survey. In 1866 he went to London on leave of absence and, at his own expense, to bring the ailing Bache home to New York.

Davidson was now, at 42 years, entering into the period of his greatest responsibilities and some of his greatest achievements. Thus, early in 1867 he was detailed on duty as engineer of a party sent to Panama to search for the best location for

a ship canal. In August, 1867, he was in Alaska making a preliminary geographical survey of that territory, the purchase of which was then being negotiated by the United States. This assignment was doubtless in appreciation of his ability to make reconnaissances quickly and adequately. In November he submitted a report on Alaska. This was of necessity largely based on information derived from Russian surveys, but it also made use of the knowledge of the principal Indian Chief of Alaska, who knew his vast territory as no one else. The Chief made a map of it for Davidson and gave him information that even the Russians did not have. Davidson always got on with Indians—he treated them as men. The report met the warm approval of Secretary of State Seward and greatly influenced the consummation of the purchase. In 1869 he visited Alaska again and observed the solar eclipse of August 7 on the Chilkaht River.

In 1868 Davidson was promoted to take charge of the U. S. Coast Survey on the Pacific Coast, a position which he retained until June, 1895. In this capacity he not only directed the work of the various field parties and made some notable geodetic and astronomical surveys but he served on government commissions in various parts of the world.

Davidson was now coming to be recognized as the leading man of science on the Pacific Coast. In November, 1870, he was elected by the regents of the University of California as professor of astronomy and geodesy (non-resident and without salary since he was a salaried officer of the government.) In 1872 he was elected president of the California Academy of Sciences and continued as such until 1887. In March, 1874, he was detailed to give special instruction in the University on the methods employed in the Survey. Later in the year he went to Japan to observe the transit of Venus and continued around the world under a government commission to investigate the methods of irrigation in India, Egypt, Italy and Holland. In June, 1877, he became a regent of the University of California. In 1878 he visited the Paris exposition to examine instruments of precision; in 1882 he went to New Mexico to

observe another transit of Venus. In 1881 he was instrumental in organizing the Geographical Society of the Pacific of which he acted as president until his death.

Many scientific societies elected him to membership: Bureau des Longitudes de France; Berlin Geographische Gesellschaft; Royal Geographical Society; Scottish Royal Geographical Society; Swedish Society of Anthropology and Geography; Paris Academy, Institut de France; the Philadelphia Academy of Science in 1853; the National Academy of Sciences in 1874, and many others. In 1876 he received the degree of Doctor of Philosophy from Santa Clara College; the degree of Sc.D. from the University of Pennsylvania in 1889; and LL.D. from the University of California in 1910. Norway conferred upon him the Cross of the Royal Order of St. Olaf in 1907, and the American Geographical Society awarded him the Charles P. Daly Medal in 1908.

He was called upon by the federal government for many special services. Thus in 1872 and again in 1884 he was appointed by the President upon the Assay Commission to test the weight and fineness of the coins of the Philadelphia mint and in both instances made all the weighings and introduced new methods. Twice he was appointed by the Secretary of the Treasury to examine the assay coin and bullion weights and the balances and beam of the U. S. mint at San Francisco. In 1873 he was appointed by President Grant one of the three Commissioners of Irrigation of California. In 1888 President Cleveland appointed him a member of the Mississippi River Commission. In 1889 President Harrison appointed him delegate to the International Geodetic Convention at Paris and he was commissioned to bring to Washington the international prototypes of the standard meter and kilometer. While in Europe he was received with high honors at the observatories of Paris, Berlin and Greenwich.

One of the greatest achievements of Davidson, almost equal to his definitive survey charts of the Pacific Coast line of the United States, was his measurement of the base lines upon which all distances in the extensive triangulation of the State of

California depend. The first was the Yolo base line measured twice by him in 1881 and the Los Angeles base line measured three times in 1888-89. Davidson tells of his methods in "Appendix" to the Coast and Geodetic Survey Report for 1882. The Yolo base was 17490 meters long (or more precisely as worked out from Davidson's record by C. A. Schott in Report of U. S. C. & G. Survey for 1883, 17486.51193 ± .00957 meters). The N.W. end was 80 feet higher than the other (S.E.) end. The elevation above sea level was carefully determined. For measuring, two compensated base bars 5 meters long contained in boxes were used. These rested in a "trestle" on 3-legged stands, whose feet rested on foot plates. The temperature of the box was read each time the bar was set in place; also a Broca scale that measured defect in temperature compensation. At the beginning of the day's work the base bars were compared with a standard 5-meter bar. The end points of the base having been established, the bars were kept accurately in line by telescopes and by apparatus for adjusting for altitude and azimuth. The deviation of the bar from the level was read by a device attached to each bar. The bars and operators were covered with an elongated tent-like cover, or "buggy," which was pushed along on wheels. There were twenty-one men in the base party. Davidson's account of the methods of procedure shows his meticulous care with every detail.

"Every officer and man had a specific duty assigned to him, and no deviation was allowed therefrom. The forward movement may be said to commence at the command 'Break,' when the contour slide of the forward bar was drawn back and the after bar was drawn back, lifted out of the trestle which held the box, and moved forward. The tripod men relieved the tightening of the legs, picked up the tripods and moved forward. when the tripods were put in line and in position by an officer; the plates followed and were placed outside the position of the legs; then the tripods were placed on the plates, accurately distanced, leveled and clamped. The 'buggy' moved forward as soon as the plates were passed. One officer, near the sector (leveling device), guarded the bar which remained in position. An officer then received in his hands the forward bar and was then responsible for it until the next 'break' of contact.

"The details of aligning the bar, raising or depressing the after end, making approximate contact, reading the Borda and mercurial thermometers, reading the sector and making final contact, fell into their regular and necessary sequence . . . The sector readings for inclination were checked by a re-reading, and in the second measurement one officer read the sector and left it without announcing his reading until the second officer had given the degrees and minutes."

Every precaution was taken against disturbance of the line during the night while the bars and standards were placed in position for the morning comparison. In the morning comparison of lengths of base bars and adjustment of the sectors was made; the after bar was "plumbed" over the night mark with the aid of a theodolite and at the command "Break" the bars moved forward.

The base line was all measured twice and part of it a third time. The actual time of laying the 8,494 bars, not including any delays, was 247 hours, an average of 34⅓ bars an hour. This is less than 2 minutes for all the above cited operations required for bar laying and contact making. Apparently Davidson did the final work in each bar contact. He says: "Davidson receives and controls end of bar coming in, adjusts distances, levels, aligns, makes contact by eye, directs other readings, reads Borda, makes contact under magnifier, 'Breaks,' holds back contact slide until after bar is removed." The result of all these precautions and Davidson's personal attention to the critical points was that the probable error (computed by Schott) in determination of the base line of 17,486.5 meters was 9.57 mm. or $\pm$ 0.547 millimeters per kilometer (i.e. 0.55 μ per meter). Other base lines measured earlier in the United States had a probable error of $\pm$ 2.44 μ to 1.77 μ per meter.

Dr. R. S. Holway states:

"The location of the north-eastern boundary line of California, the 120th meridian, was finally determined by him in 1873, and the diagonal boundary of 405 miles from Lake Tahoe to the Colorado River was located and marked under his supervision in 1893. This line is interesting because at each end it terminates in a body of water."

This brief account affords but an imperfect idea of the breadth and scope of the work of Professor Davidson. Says Holway:

"The fact that in all the many problems of his main work his scientific accuracy stands practically unchallenged is due to his wonderful capacity for untiring effort, to his acute eyesight as an observer, and to his fixed habit of patiently and conscientiously verifying every observation.

"In the seventies, when reoccupation of some of his old stations by later parties threw some doubt on his observations fixing the exact position of Mount Tamalpais, he boldly asserted that his work was right, that the mountain might have moved, but that he had correctly determined its location at the time. After the earthquake of 1906 there was made a careful and extensive survey of central California, which, compared with the surveys before and after the earthquake of 1868, confirmed the accuracy of Professor Davidson's original observations and also his explanation of the apparent discrepancies."

Closely associated with his geodetic work was Davidson's determination of the longitude of a point in San Francisco in 1869 after telegraphic methods became available. The San Francisco *Alta* of March 2 gives the following account of this operation which was made by connection with Cambridge, Massachusetts, and via cable with Valencia and Greenwich:

"He had, by permission of the city authorities, erected a small building of about 100 sq. ft. area on Washington Plaza. This contained a clock, to mark sidereal time, a transit instrument, or mounted telescope, a chronograph, and an operating apparatus with its batteries and telegraphic connections. There was a moveable telescope, for casual uses. It is said that Davidson had already since 1852 taken three hundred independent determinations of longitude along the coast, but his present equipment was designed to secure greater accuracy. The transit was used to determine the hours of the clocks by the transits of about 15 stars before and after exchanging clock signals. During twelve nights between February 18th and April 4th the signals were sent to Cambridge and returned. The time of passage was determined to be $\frac{9}{10}$ths of a second. The Western Union Telegraph Company cooperated cordially and without expense to participate in this public service of determining the precise longitude of San Francisco."

Davidson's early contributions to astronomy have been already cited. Some of his later astronomical activities may be quoted from the account of Dr. W. W. Campbell:

"In the late 1880's the question of the variation of terrestrial latitudes was prominent, and observations at widely separated stations were urgently called for. As a labor of love Professor Davidson undertook the observations of latitude pairs, by the Talcott-Horrebow method, at his observatory in San Francisco. Between May, 1891, and August, 1892, approximately 2500 pairs of stars were observed for this purpose; to be exact, 5308 observations on 283 stars were secured. An additional series of observations was made by him in the years 1893-94. The results agreed with those secured at European, Atlantic Coast and Hawaiian stations, confirming the fact that the latitudes of points on the earth's surface are constantly changing by minute amounts.

"Professor Davidson's programs of observation, whether for the determination of latitude, time and azimuth, of magnetic declination and dip, of refraction constants, or for research in pure astronomy on his own account, were characterized by the very great numbers of observations planned for and secured, as well as by the observance of precautions for ensuring that the individual observations be as accurate as possible.

"It is a remarkable fact that the first investigating astronomical observatory planned for California, and in fact for the western half of the United States, the Lick Observatory, was on a large scale for its time. The first observatory completed in California, however, was that of Professor Davidson. This was established in LaFayette Park, San Francisco, about 1879. It was erected at Davidson's personal expense. It contained a 6.4 inch Clark refracting telescope. This instrument was used to observe the total eclipse of January 11, 1880, on Santa Lucia Mountain; to observe several partial solar eclipses and the 1882 transit of Venus; to make drawings of the principal planets; and to observe star occultations and comets. The observatory was dismantled several years ago, following a permanent affection of Professor Davidson's eyesight, which prevented him from making further observations."

One of the greatest contributions made to astronomy by Davidson was an indirect one. It appears that attached to the Central High School of Philadelphia was an astronomical observatory and two men whose names later became linked with

astronomy observed there. One was Charles Tyson Yerkes, who later distinguished himself in Chicago traction and who gave to the University of Chicago the great observatory that bears his name. The other was Davidson, who came to know, at San Francisco, James Lick who had become wealthy in dealings in real estate. William Churchill writes in the Bulletin of the American Geographical Society for 1912:

"James Lick was seeking to dispose of his wealth. He had no knowledge of astronomy, no interest in the science, but he knew Davidson and respected the man who disregarded money-making for a higher though less gainful pursuit. His thought was drawn in the direction of a great telescope. He learned from Professor Davidson that the greatest refractor was thirty inches. His idea was to multiply the Poltava glass by two; in other words, California should have a five-foot glass. He wrote in his will that the glass to bear his name should be twice as large as the biggest in the world. It took long argument from Davidson to secure the formation of a plan which was within human possibility. The observatory which crowns Mount Hamilton in the dry sky above the Santa Clara valley is the Lick Observatory, but we owe it to George Davidson.

"Word came to Professor Davidson, one day, that a butcher in Oakland was working to become an astronomer, beginning at the bottom, striving to make his own telescope and mount. Davidson went across the bay and talked astronomy to the butcher, took him to his own observatory on the summit of a San Francisco hill and gave the young enthusiast his first glimpse at the heavens through a powerful equatorial. Together they worked over the young man's home-made observatory. In Oakland a certain rich man and George Davidson brought it to pass that the wealth of the rich man and the butcher's zeal for the heavenly science were harnessed for the public good. The city of Oakland was the first city of the world in which an observatory was made a part of the public school system, the Chabot Observatory; and the butcher who had sacrificed so much to make his own glass was appointed Director and had the rare pleasure of installing a good glass."

In connection with his astronomical and geophysical work must be mentioned one invention which grew out of his recognition of the weak points in existing instruments employed by the Coast and Geodetic Survey. His inventive genius suggested

many improvements which were embodied in the Davidson meridian instrument for determining time, longitude and latitude, described in the Survey report for 1867. This instrument was extensively used in subsequent work of the Coast Survey throughout the United States.

Among his 260 publications, books, pamphlets and papers, is included his "Pacific Coast Pilot," a volume of 700 pages with much valuable historical and geographical information; also two field catalogs of time stars, one of 983 and the other of 1278 stars and a table of star factors A, B and C for the reduction of time observations.

The last few years of Davidson's life were spent in comparative quiet, but though enfeebled physically he remained alert of mind, maintained an active interest in scientific matters and retained his wonderful memory and wrote articles on geographical subjects to the end. He contracted a severe cold which affected his heart, weakened by age, and so he died at his residence in San Francisco in his eighty-seventh year.

George Davidson, born of a race that lived on the mountains of Scotland near the seashore, came to be active among the mountains and on the sea coast removed one-third way around the globe. Amidst a crowd of fortune-seekers, adventurers and speculators he stood as a representative of solid, accurate applied science and contributed perhaps more than any other one man to the early development of San Francisco as a scientific center.

According to Dr. Alexander McAdie, who knew him well in California, Davidson was about five feet eleven inches in height with white beard and piercing eyes. Straight as an arrow he walked with the easy swing of a sailor. In the earlier part of his life in California he was more or less profane, using a picturesque English acquired on the Brig when he had to command a crew of rough sailors in a way they could understand and obey; and later useful in dealing with sea-faring men. But this habit was abandoned after he was appointed

Professor of Geography at the University of California at Berkeley. Miss Davidson says:

"The University asked him to organize a College of Commerce, something new at that time. There were no text books and nothing to go on. He used his own books and maps and wrote his lectures from his own fund of knowledge—they add considerable bulk to his other writings. He lectured only, and to large classes of seniors only. The course was very popular because he found jobs for those who intended making commerce a profession. When it became a 'going concern,' that is a regular part of the University, Mr. Holway took it over."

Says McAdie,

"Twice a week or so he went over from his city home and at the lunch hour about eight of the professors would gather in Professor Armes' room at the Club and there we were all boys together.

"His appointment to the University came about after his abrupt dismissal from the Coast and Geodetic Survey. . . . It was a time of 'slaughter' (as the administration changed and he had reached the age limit.)

"He was naturally interested in seismology. He was long president of the American Seismological Society. And in 1865, after a severe shock he and his son fixed up a rough seismograph in his home."

Holway writes of him:

"Simple and unassuming in appearance, he bore the mark of one accustomed to command, and possessed a strong and dominating personality. The men who served under him learned at once to obey unquestioningly his slightest order, yet his warm-hearted and generous nature caused them to be strongly attached to him. It has been said that his life work extended through sixty-eight years of active manhood, and rightly so, although one infirmity partially disabled him in later years. He was made Professor Emeritus in 1905 and freed from any obligation to do University work, yet he voluntarily continued his classes for two years in spite of failing eyesight. The necessity of submitting to an operation for cataract finally compelled him to give up lecturing. Although the operation was but partially successful, several papers were prepared by him in these later years. Professor Davidson's indomitable will kept him at work when he was able to read only

through a narrow slit in blackened cardboard under favorable light and with the help of the strongest glasses.

"Under such circumstances he wrote and published in 1908 his paper on 'Francis Drake on the Northwest Coast of America', and in 1910, the paper on 'The Origin and Meaning of the Name California.' Both these papers necessitated the careful reading of old maps and manuscripts and yet every point was verified and compared in his manuscript and also in final proof with his original source of information.

"To the last he stood as erect as a young soldier, and his voice rang with the courage that he never lost. To those who knew him personally his memory will be treasured because of his warm heart and manly character. The record of his life is an inspiration toward untiring conscientious scientific work."

His daughter, Ellinor Davidson, states that his parents had planned educating him for the church.

"He was reading in the Bible at four, in the Latin Bible at six, and knew the hymns of that period by heart. The early hair-raising sermons on predestination (19th and lastly) preached in Philadelphia at that day served to turn him away. He thought it a horrible and untrue doctrine. Instead he became a scientist and a Mason. But he knew the Bible from beginning to end, and asked his friends among the Jews (Rabbi Voorsanger) to translate passages which are known to be incorrectly done into English. He corresponded with the two English women who discovered the versions of the testament in Syria, etc. He loved Shelley and Homer. He believed Bacon wrote Shakespeare, and corresponded with Mrs. Gallop and Dr. Owen who did the deciphering. He tried his own hand at it and a passage in Latin came out to his delight."

At his death the editor of the *San Francisco Call* wrote:

"This kindly and gentle old man always held a wonderful store of scientific knowledge at the service of the people. Among newspapermen an especial favorite because of the pains he was always ready to take to explain difficult problems of current interest. Always accessible and liberal of his store of knowledge, his house on the hill was the constant resort of seekers after information on topics of scientific interest and difficulty.

"Professor Davidson was keenly interested in everything relating to the sea. All the old mariners knew him and trusted him implicitly. They brought to him all records of strange happenings and went to him for advice, which was always forth-

coming and invariably good. He made a special study of shipwrecks and has helped more than any one man to make safe travel by water along this coast."

George Davidson, a child of a race that was of the sea and the mountains, with limitless energy, an extraordinary memory for the countless things that interested him, a lover of the detail as well as the vast universe of the stars, who considered thousandths of a millimeter in the measurement of base lines that the form of the earth might be accurately ascertained, was a man born to command and one who at the same time made firm friends of his associates in science and the world of affairs. Coming early to the Pacific coast, against whose hidden dangers navigators were inadequately warned, he soon became responsible for the proper placement of light houses and beacons and the making of accurate coastal charts for a distance of two or three thousand miles. He was both a distinguished cartographer and an expert on maps. His name is preserved in connection with a number of physical features of the coast. A list of places named after him has been provided by Miss Davidson.

Davidson Glacier	Lynn Canal, Alaska, named for G. D. in 1867 by the Superintendent of the Coast Survey.
—— Point	In front of Davidson Glacier, so called by Meade, 1869.
—— Inlet	South of Kosciusko Is., Prince of Wales Arch., by Dall, 1879.
—— Mountain	S. side Sanborn Harbor, Nagai Is. Shumagin Group, by Dall in 1872.
—— Bank	Near Unimak Pass, Aleutians, by Fish Commission, 1888.
—— Range	Arctic Alaska, *west* of the boundary, by Capt. John Turner of Alaska-Canada boundary, 1890.
——'s Rock	Discovered by G. D. in 1854 and named Entrance Rock. In Rosario Strait, a submerged Rock. Put on British maps as Davidson's, and the name remained.

Davidson's Point	On Royal Geographical Society Island, Victoria Strait, Queen Maud's Sea, named by Capt. Roald Amundsen. See Hansen's map end of Vol. II of the "North west Passage" by R. A.
Mount Davidson	Highest hilltop in San Francisco.

An "extinct whale from California" discovered by Prof. E. D. Cope near San Diego, was named Eschrichitus davidsonii.

BIBLIOGRAPHY OF GEORGE DAVIDSON

As an assistant in the U. S. Coast and Geodetic Survey, engaged chiefly in field work, many of Davidson's field reports are embodied in the Annual Reports of the Superintendent of the Survey rather than in separate "papers." Many of his data were discussed and published under the name of the statistician of the Survey, Charles A. Schott.

1845-95

Geographical, Geodetic, and Magnetic Work by George Davidson on the Atlantic, Gulf, and Pacific Coasts. U. S. Coast and Geodetic Survey Reports.

Annual Reports of the Superintendent of the U. S. Coast and Geodetic Survey from 1845-1895 include reports of Field Work, Methods and Instruments of George Davidson.

1853

Discovery and Observations upon a Brilliant Comet at Astronomical Station, Astoria, Columbia River. Report Supt. U. S. Coast Survey. July.

1855

Table of the Geographical Positions of Forty Astronomical Stations on the Pacific Coast of the United States, 1850-1855. Alta California, May.

1856

Occultation of Stars by the Moon on Western Coast of the United States in 1856. U. S. Coast Survey Report, pp. 203-8.

1857

The Occultation of 22 Stars of the Pleiades, and Solar Eclipse of 1857. U. S. Coast Survey Report.

Directory of the Pacific Coast. U. S. Coast Survey Report, 166 pp.

Testimony before the Judge of the U. S. District Court of California, Northern District, Proving the Forged Seals on the Eleven League Grant to Limantour, which covered San Francisco. Alta California, Nov. 4.

1862

Directory of the Pacific Coast of the United States, or Coast Pilot of California, Oregon, and Washington. U. S. Coast Survey Report, 160 pp.

1863-4

Examination and Report of the Lines of Defence of Philadelphia, between the Delaware and Schuylkill Rivers. U. S. Coast Survey, 1864.

1865

Sextant with Attached Spirit Level Horizon. Franklin Inst. Journ. 4 pp., 1 plate.

1866

Hydrographic Examination of the Entrance to Saco River, Maine, for Improvement to Navigation. U. S. Coast Survey Report, 1866.

1867-89

Papers upon the Ocean Currents off the Pacific Coast of the United States; the Waters of the Kuro Siwo, etc. Official Report of 1867, Cong. Doc. No. 177, 40th Cong., 2nd Sess. and California Academy of Sciences at various times to 1887. Coast Pilot of Alaska, 1869; Coast Pilot of California, Oregon, and Washington, 1889.

1867

New Meridian Instrument for the Determination of Time, Latitude and Azimuth. U. S. Coast and Geodetic Survey Reports, 1867; sec. ed. 1879.

Report upon the Geographical Reconnaissance of the Coast of Alaska. The Physical Features and Prospective Resources of that Territory, and Proposed Aids to Navigation. Ex. Doc. No. 177, H. of R., 40th Cong., 2nd Sess., 8vo, pp. 219-360.

1868

Compilation and Drawing of Three Charts of the Coast of Washington, British Columbia, Alaska. U. S. Coast Survey Report.

Condensed Account of M. Hellert's Exploration of the Isthmus of Darien. Project for Exploration. U. S. Coast Survey Report, pp. 260-277.

Resources of Alaska. Lippincott Mag., Nov., 19 pp.

1869

The Total Solar Eclipse of August 7, 1869, Chilkaht River, Alaska. U. S. Coast Survey Report. 5 pp., plate.

Coast Pilot of California, Oregon, and Washington. U. S. Coast Survey Report, 262 pp.

Observations of the Meteors of November 14, 1869, at Santa Barbara. Proc. Cal. Acad. Sci., Vol. 4, part 3; also Amer. Journ. Arts and Sci.

Coast Pilot of Alaska, First Part, from the Southern Boundary to Cook's Inlet, 1869. U. S. Coast Survey, 252 pp., 8 illus.

1870

Changes of Verticality and Azimuth of Station Dominguez, Los Angeles Plains, Cal., Caused by Heat Action of the Sun. U. S. Coast and Geodetic Survey Report, pp. 178-9.

Large Deflection of Plumb Line at Coast Survey Astronomical-Geodetic Stations. Proc. Cal. Acad. Sci., Vol. 4, part 3, p. 148.

Effect of Temperature on the Sand Stone Bluff near Buena Ventura, Sta. Barbara Channel. Proc. Cal. Acad. Sci., Vol. 4, part 3.

Ocean Current off Cape San Lucas, Lower California. Proc. Cal. Acad. Sci., Vol. 4, part 3.

Table of the Azimuth and Apparent Altitude of Polaris at all Hour Angles for Latitudes 30°-60°. U. S. Coast Survey Report.

Observation of the Meteors of November 13-14, 1870, at San Francisco. Proc. Cal. Acad. Sci., Vol. 4, part 3.

1871

Report of the Examination of Weights and Balances, Branch Mint of the United States, San Francisco, to the Honorable Secretary of the Treasury. 30 pp.

Comparison of the Methods of Determining Heights by Leveling, Vertical Angles, and Barometric Measures, between Ross Mt. and Bodega Head in 1860. Discussion by George Davidson and Chas. A. Schott. U. S. Coast and Geodetic Survey Report, pp. 154-170.

1872

The Relative Value of Great and Small Elevations for Astronomical Observations. Proc. Cal. Acad. Sci., Vol. 4, part 5, pp. 251-252.

Report upon a Proposed Canal through Mission Creek and Channel Street, Mission Bay, for Navigation and Drainage. Pamphlet, pp. 29-42.

Earthquake Waves at San Francisco. Aug. 24, 1872. Proc. Cal. Acad. Sci., Vol. 4, part 5, pp. 268-9.

The Bommerangs Used by the California Indians. Proc. Cal. Acad. Sci., Vol. 4, part 5, p. 233.

Report upon Astronomical Observations at Great Elevations in the Sierra Nevada, 7,200 feet. U. S. Coast and Geodetic Survey Report, pp. 173-176.

1872-79

Twenty-four New Problems in Mensuration. Cal. Acad. Sci., 18 pp., with 8 figures; Oct. 21, 1872; May 19, 1873; March 3, April 7, 1879.

1873

First Announcement that James Lick would build a Great Telescope in the Sierra Nevada at 10,000 feet elevation. Cal. Acad. Sci., Oct. 20, 1873.

The Auriferous Gravel Deposits of California. Proc. Cal. Acad. Sci., Vol. 5, part 2, pp. 145-146.

On an Improved Prismatic Telemeter for Reconnaissance, Engineering, and Military Purposes. Proc. Cal. Acad. Sci., July 21, Vol. 5, part 2, pp. 134-137, illus.

On an Improved Leveling Rod. Cal. Acad. Sci., Sept. 1, 2 pp.

Hieroglyphics of Easter Island, South Pacific. Proc. Cal. Acad. Sci., Vol. 5, part 2.

Dangers to Navigation in the Approaches to San Francisco. Chamber of Commerce, San Francisco, December 9, 1873. Alta California, Dec. 10.

Abrasions on the Northwest Coast of America and the Supposed Ancient Sea Levels. Proc. Cal. Acad. Sci., 1873, Vol. 5, part 1.

In Memoriam, Louis Agassiz. Cal. Acad. Sci. Memorial Meeting, Dec. 22, 8 pp.

1874

New Vertical Clamp for Astronomical and Geodetic Instruments. U. S. Coast and Geodetic Survey Reports. Sep. ed. 1874 and 1879. 2 pp., illus.

Report of Commission upon the Irrigation of the Sacramento, San Joaquin, and Tulare Valleys of California. Ex. Doc. 290, H. of R., 43rd Cong., 1st Sess. 61 pp., 6 maps (by the three Commissioners).

Mesh Knot of the Tchim-chae-an Indians, Port Simpson, B. C. Cal. Acad. Sci., Oct. 19, 3 pp., 4 illus.

The Necessity for a Physical Survey of California. Cal. Acad. Sci., 6 pp.

The Endowment of Scientific Research. President's Annual Address, Cal. Acad. Sci., 8 pp.

Field Catalogue of 983 Transit Stars. Mean Places for 1870.0 with Annual Variation. U. S. Coast and Geodetic Survey Report, 33 pp.

Announcement that James Lick would build and equip an Edifice for the California Academy of Sciences, also that the California Academy of Sciences was to be Trustee of the James Lick Observatory. President's Annual Address, Cal. Acad. Sci., Jan. 5.

The Recovery of the French Transit of Venus Station, Lower California, 1769. Proc. Cal. Acad. Sci., Vol. 5, part 1, pp. 65-67.

The Star Factors A. B. C. for Reducing Transit Observations: 57,500 to 3 places of decimals. U. S. Coast and Geodetic Survey Report, p. 70.

1875

Geographical Positions and Telegraphic Difference of Longitude between Nagasaki, Vladivostok, and Tokyo, 1874. U. S. Coast and Geodetic Survey Report.

Observations on Certain Harbor and River Improvements Collected on a voyage from Hong Kong via Suez to New York. Breakwaters, etc. U. S. Coast and Geodetic Survey Report. 22 pp., 12 illus.

Report upon the Methods Employed in Irrigating Land in India, Egypt, Italy, and other countries. Ex. Doc. 94, Senate, 44th Cong., 1st Sess., 73 pp., 23 maps.

1876

A series of papers read before the Cal. Acad. Sci. on Irrigation and Reclamation in India, Egypt, Italy, etc.; the Improvement of Harbors and Rivers; and the Breakwaters of Egypt, Italy, France, Prussia and England. Evening Bulletin, April 7, 1876; May 3, 1876; June 10, 1876; December 8, 1876; December 20, 1876; January 17, 1877; February 8, 1877; February 24, 1877.

New Break Circuit Chronometer, 4 pp. with illus. Min. and Sci. Press.

1877

Two Addresses before the Legislature of California, by Resolution, etc., upon Irrigation in India, Egypt, Italy, and California. Sacramento Record-Union, February 17, 18, 1877.

Mechanical Defects of the Micrometer Screw, 5 pp. with illus. Min. and Sci. Press.

Report upon a Scheme of Irrigation for the Waters of the Merced River. Pamphlet. 9 pp.

1878

Geodetic Instruments of Precision at the Paris Exposition and in European Workshops. Read before Nat. Acad. Sci., Nov. 1878. Printed privately.

1880

Harbors of Refuge on the Pacific Coast of the United States. Morning Call, May 20; Evening Bulletin, May 27.

The Pacific Coast and Geodetic Surveys. Californian, January, 8 pp.

1881-94

Reports upon the Observation of the Transits of Mercury in 1881, 1891, 1894. U. S. Coast and Geodetic Survey Reports.

1881

Memorial for the Survey of Alaska. Chamber of Commerce, San Francisco. Geographical Society of the Pacific. Chronicle and Alta California, Dec. 30.

Comets. Cal. Mag., Oct., 13 pp.

1882

Science in the Public Schools. President's Annual Address. Cal. Acad. Sci., 6 pp.

Observations upon the Great Comet of September, 1882, at Mt. Tamalpais. Cal. Acad. Sci.

The Measurement of the Yolo Base Line in Yolo County, Cal. Length 17,486 meters measured twice with compensating bars in 1881. U. S. Coast and Geodetic Survey Report. 11 pp., and 20 illus. with maps.

1883

The New Volcano St. John Bogoslov (St. John the Divine) in Bering Sea. Cal. Acad. Sci., 1883. Science, Vol. 3, p. 282.

Plover Island, Part of Wrangell Land, Arctic Ocean. Proc. Cal. Acad. Sci., Vol. 4, part 5.

Examination of the Carson Foot Prints. Cal. Acad. Sci., Sept. 15 and 22, 8 pp.

Determination of the Coefficient of Refraction by Observation of Leveling, Vertical Angles of Zenith Distances, Barometric Measures and Boiling Water; Observations between Martinez and Mt. Diablo. Discussion by Chas. A. Schott. U. S. Coast and Geodetic Survey Report, pp. 289-321, 1 plate.

1884

The Reported Shoaling of the Bar at the Entrance to San Francisco Bay. Chamber of Commerce, 4 pp. Min. and Sci. Press.

Heights of the Stations of the Davidson Quadrilaterals from Trigonometrical Determinations. Observations by George Davidson. Discussion by Chas. A. Schott. U. S. Coast and Geodetic Survey Report, pp. 391-405.

Notes on the appearance of Saturn. Bull. Cal. Acad. Sci., I, No. 1, pp. 48, 49.

Annual Solar Eclipse, Oct. 30, 1883. Bull. Cal. Acad. Sci., I, No. 1, Feb., pp. 49-51.

A Brilliant Meteor. Bull. Cal. Acad. Sci., I, No. 1, p. 51.

Intra-Mercurial Planets. Bull. Cal. Acad. Sci., I, No. 1, pp. 51-54.

The Pons-1812 Comet. Bull. Cal. Acad. Sci., I, No. 1, pp. 54-55.

The Planets Mars, Jupiter and Saturn. Bull. Cal. Acad. Sci., I, No. 1, pp. 55-57.

Observations of Occultations of Stars by the Moon and Phenomena of Jupiter's Satellites. Mon. Not. Roy. Ast. Soc., March, pp. 268-273.

The First Ascent of Volcano Makúshin, Unalaska Isd., Alaska, in 1867. Appalachia, Vol. 4, No. 1, Dec. 1884, 12 pp., map and view.

The Shoaling of the Bar at the Entrance to San Francisco Harbor. Geographical Society of the Pacific. Pamphlet, 24 pp.

Observations of Occultations of Stars by the Moon during the Total Eclipse, June, 1881. Mon. Not. Roy. Ast. Soc., March, p. 268.

Transit of Venus, Cerro Roblero, New Mexico, 5,500 feet elevation; Observations and 216 Photographs: Geographical Positions, Telegraphic Longitude, etc. U. S. Coast and Geodetic Survey and U. S. Transit of Venus Commission.

Dark Transits of Jupiter's Satellites, 1884. Sid. Mess., May, pp. 124-127, two illustrations.

1885

Connection of the Yolo Base with the Primary Triangulation of California, including a Reduction and Adjustment of the "Davidson Quadrilaterals": Observ. by George Davidson; discussion by Chas. A. Schott. U. S. Coast and Geodetic Survey Report, pp. 441-468.

Magnetic Data Collated from Manuscript Reports of Spanish Navigators on the Northwest Coast of North America from 1774 to 1793. U. S. Coast and Geodetic Survey Report.

1886

Black Transits of Jupiter's Satellites, III and IV. Bull. Cal. Acad. Sci., I, No. 4, pp. 339-342.

The Dark Transit of Jupiter's Satellite, IV. Bull. Cal. Acad. Sci., I, No. 4, pp. 342-344.

Transit of Jupiter's IV Satellite, June 7, 1885. Bull. Cal. Acad. Sci., I, No. 4, pp. 345-347.

"Sporadic" Meteors Recorded during 1882. Davidson Observatory. Bull. Cal. Acad. Sci., I, No. 4, p. 348.

Observations on the "Pons-Brooks" Comet. Bull. Cal. Acad. Sci., I, No. 4, p. 349.

Phenomena of the Satellites of Jupiter. Bull. Cal. Acad. Sci., I, No. 4, pp. 350-351.

Occultations of the Stars by the Moon Observed at the Davidson Observatory during the year 1884. Bull. Cal. Acad. Sci., I, No. 4, pp. 352-353.

The Temperature of the Water of the Golden Gate. Daily Observations for Ten Years, 1874-83. Bull. Cal. Acad. Sci., I, No. 4, pp. 354-357, tables and curves.

Report upon a System of Sewerage for the City of San Francisco. Requested by Resolution of the Board of Supervisors, April, 20 pp.

Upon the Deep Sea Harbor at San Pedro and Santa Monica. Ex. Doc., H. of R., No. 41, 52nd Cong., 2nd Sess., 3 pp.

An Examination of the Voyages of Discovery and Exploration on the Northwest Coast of America from 1542 to 1603, being an Identification of the Landfalls of Ulloa, Cabrillo, Ferrolo, Drake, and Viscaino. Annual Report of the U. S. Coast and Geodetic Survey, and two separate editions, 100 pp. and 1 map.

Dark Transits of Jupiter's Satellites, 1886. Bull. Cal. Acad. Sci., pp. 89-90.

Standard Geodetical Data, California. Bull. Cal. Acad. Sci., No. 6.

Saturn. Fifteen-inch Drawing, March, 1886, reproduced by photography.

The Submarine Valleys on the Pacific Coast of the United States. Bull. Cal. Acad. Sci., No. 6.

Observations on Solar Eclipse, March 5, 1886. Bull. Cal. Acad. Sci., No. 5, pp. 91-92.

Transits of II and III Satellites of Jupiter. Bull. Cal. Acad. Sci., No. 5, pp. 89-90.

1888

The Resources and Development of Alaska. U. S. Coast and Geodetic Survey Bull., No. 4, Vol. 1, 12 pp.

The Magnetic Variation at San Francisco. Min. and Sci. Press, Jan. 28, four columns with tables, etc.

The Total Solar Eclipse of January 1, 1889. Prediction, Data, Path; Instructions to Observers. San Francisco Call, Dec. 16, 1888.

1889

Measurement of the Los Angeles Base Line, Cal. Length 17,495 metres, measured three times with compensating bars in 1889. U. S. Coast and Geodetic Survey Report, pp. 217-231, 8 illus., with maps.

Sketch of the Life and Work of Dr. Albert Kellogg. West American Oaks, pp. V-VII.

Coast Pilot of California, Oregon, and Washington (wholly rewritten). U. S. Coast and Geodetic Survey, 721 pp., 464 views, and 1 chart.

The Davidson Inshore Eddy Current on the Coast of California. Proc. Cal. Acad. Sci., Vol. 4, part 3, p. 150. Coast Pilot of California, Washington, and Oregon.

1890

Association Géodésique Internationale, IX Conference, Paris, Oct. 1889; Address by G. D. U. S. Coast and Geodetic Survey Report, pp. 721-733.

In the Matter of the Spoliation of Yosemite Valley: Report to the Honorable Secretary of the Interior. Annual Report of the Yosemite Commissioners.

The Identification of Sir Francis Drake's Anchorage on the Coast of California in the year 1579. 58 pp., 15 maps and views, California Historical Society.

The Apparent Projection of Stars and Planets on the Bright Limb of the Moon at Occultations. Mon. Not. Roy. Ast. Soc., May.

The Recent Volcanic Eruption of St. John Bogoslov (St. John the Divine), Bering Sea. Bull. Amer. Geog. Soc., June 30, pp. 267-272.

1891

The Discovery of Humboldt Bay, California. Geog. Soc. Pac., 16 pp., 5 maps and views.

1892

The Occupation of Mt. Conness, 12,556 feet elevation. Overland Monthly. pp. 114-129, with 13 illus.

The Total Solar Eclipse of January 11, 1880, at Mt. Santa Lucia, 6,000 feet elevation, Cal. U. S. Coast and Geodetic Survey Report.

A Few Incidents in Conference with James Lick. Overland Monthly, pp. 482-3.

New Microscopic Method for the Determination of the Irregularities in One Turn of the Micrometer Screw and for Determining the Relative Values of each Turn. U. S. Coast and Geodetic Survey Report, 7 pp.

An Account of the Eruption of the Volcano Weniaminof, Alaska Peninsula. History and Geographical position.

Report upon 1,205 Meteors Observed in Andromeda, and Change of Radiant, November 23, 1892. Daily press; Sid. Mess.

1893

On the Variation of Latitude at San Francisco, California, from (6,768) Observations Made in Cooperation with the International Geodetic Association, 1891-92: Observations made by George Davidson. Discussion and Report by Chas. A. Schott. U. S. Coast and Geodetic Survey Report, pp. 445-508, and two sketches.

1894

Report on Base Lines in the Geodetic Conference of the Coast and Geodetic Survey at Washington, p. 17; General Rept. of the Geodetic Conference, 1894, p. 16. U. S. Coast and Geodetic Survey Report, 1893.

Historical Essay at the Unveiling of the Prayer-Book Cross, Golden Gate Park, Jan. 1, 1894. Chronicle, Jan. 2.

Early Spanish Navigators. Illustrated Pacific States, October, 6 cols., 1 illus.

Early Voyages on the Northwest Coast of America. Geographic Conference, Columbian Exposition, Chicago, 1893. Nat. Geog. Mag., Vol. 5, pp. 235-256.

The Constant of Aberration as Determined from (6,768) Observations of Latitude at San Francisco, California: Observations made by George Davidson. Discussion and Report by E. D. Preston. U. S. Coast and Geodetic Survey Report, pp. 111-120.

1895

Report upon the Engineering and Topographical Features of the Stanislaus and San Joaquin Water Company. Pamphlet, pp. 8-46, map and 7 illus.

1896

Report to the San Francisco Committee of Commerce on the Dangers and Aids to Navigation in San Francisco Bay and the Approaches; with a Record of 349 Wrecks and Casualties. Pamphlet, 16 pp., Jan. 9.

Irrigation Rates for Water. The Graphic, Stockton, Cal., Apr. 18.

Report upon the Genuineness of the "Jeannette" Relics and Evidences of Arctic Drift. Geog. Soc. Pac., 16 pp., May.

Report of the Board of Consulting Engineers to the Land Owners of Reclamation District No. 108, Sacramento Valley. 48 pp. and maps, July.

1897

Document: The Identification of the Body of James Lick upon placing it beneath the Pier of the Great Equatorial at Mt. Hamilton. San Francisco papers Jan. 8 and 9, and photographs of original.

The Submerged Valleys on the Coast of California, U. S. A., and of Lower California, Mexico. Proc. Cal. Acad. Sci., third series, Vol. 1, No. 2, pp. 71-103, with 9 plates and 20 illus. June.

Alaska. Overland Monthly, November, 11 pp., 7 illus.

1898

The Area and Number of the Philippine Islands. Amer. Geog. Soc. Bull., No. 2.

Physical Features, Cost and Resources of Alaska. Congressional Record, March 4, pp. 2,775-2,779.

Discussion upon the Names of the Larger Geographical Features of North America. Bull. Geog. Soc. Philadelphia, November, Vol. 2, No. 4, pp. 63-64.

1899

The Change of Date Line ("the line separating the lands of the Pacific where American date is kept from those where Asiatic date is kept"). Pilot Chart of the North Pacific, Hydrographic Office Navy Department. August; also Pilot Chart of North Atlantic, Sept.

Report to President Wheeler upon the Collection of the Philadelphia Commercial Museum, its Methods, Administration, etc. Univ. Chronicle, Vol. 2, No. 5.

A similar report to the San Francisco Chamber of Commerce. Published by Chamber of Commerce in pamphlet, November, 11 pp.

1900

The College of Commerce. Univ. Cal. Mag., February.

The Lynn Canal and the Taiyá Inlet—A Chapter in the Physical Geography of Southeastern Alaska. Bull. Geog. Soc. Philadelphia, March, Vol. 2, No. 5, pp. 108-114.

The Pacific Commercial Museum. Commercial News Annual Review, San Francisco, July, pp. 30-33.

Two Eruptions of Mount Baker. Northwest Farm and Home, Seattle, Dec. 6.

The apparent projection of Stars upon the bright limb of the Moon at occultation, and similar phenomena at Total Solar Eclipses, Transits of Venus and Mercury, etc. Proc. Cal. Acad. Sci. Third Series. Math.-Phy., Dec., Vol. 1, No. 7, pp. 64-102.

1901

The Track and Landfalls of Bering and Chirikof on the Northwest Coast of America; from the Point of their Separation in Latitude 49°, 10′, Longitude 176°, 40′ West, to their Return to the Same Meridian. June, July, August, September, October, 1741. San Francisco, October, Private publication, 44 pp. with large map.

Explanation of an Indian Map of the Rivers, Lakes, Trails, and Mountains from the Chilkaht River to the Yukon River, drawn by the Chilkaht chief, Koh-Klux, in 1869; Mazana, Portland. April, pp. 75-82, with map.

1902

The Administration of Alexander Dallas Bache, LL.D., as Principal of the Central High School of Philadelphia. 1838-1842, *in* The History of the Central High School of Philadelphia, by F. S. Edmonds, A.M., Philadelphia, January, pp. 74-80.

Soft iron in Lituya Bay, Alaska. New York, The Mineral Collector, Vol. 9, No. 1, March, pp. 12-13.

The Currents and Climatology of the North Pacific. San Francisco, Commercial News and Shipping List, June 5.

The Copper River of Alaska. San Francisco, Trans. and Proc., Geog. Soc. Pac., Vol. 1, Series 2, pp. 44-50.

Cape Nome—the origin of the name. San Francisco, Trans. and Proc., Geog. Soc. Pac., Vol. 1, Series 2, 1902.

1903

Rainfall: Numerical and graphic exhibit of the annual rainfall in inches at San Francisco for each wet season from 1849 to 1903, both inclusive. Daily Commercial News, San Francisco, Nov.

1904

The Alaska Boundary. Published by the Alaska Packers Assoc., San Francisco. Press of "The Bosqui Engraving and Printing Company," March, 1904, 235 pp. and 3 charts.

The Glaciers of Alaska that are shown on the Russian Charts or mentioned in older Narratives. Trans. and Proc., Geog. Soc. Pac., Vol. III, Series II. San Francisco, June 1904; pp. viii, 98; and 11 charts.

1906

Currents of the North Pacific and Their Dangers. Commercial News, San Francisco, 2 cols., Sept. 5.

Northwest Currents—the inshore eddy current along the Northwest Coast of America. Daily Commercial News, Jan. 27.

1907

The Discovery of San Francisco Bay, the Rediscovery of the Port of Monterey, the Establishment of the Presidio, and the Founding of the Mission of San Francisco. Geog. Soc. Pac., 153 pp., 8vo., San Francisco, May.

The name "Mt. Rainier," Sierra Club Bull. No. 35, Jan., pp. 87-99.

1908

Francis Drake on the Northwest Coast of America: The Golden Hind did not enter the Bay of San Francisco. Trans. and Proc., Geog. Soc. Pac., Series II, Vol. V, 1908. 114 pp.

U. S. Transit of Venus Expedition to Japan in 1874. Berkeley Lyceum, Aug.

1910

The Origin and Meaning of the Name California: Calafia the Queen of California. Geog. Soc. Pac., Vol. 6, pt. 1, 60 pp., May.

The Discovery of America by the Norsemen, and Their Attempt at Colonization, by Gustave Niebaum. (Introduction.) Geog. Soc. Pac., Vol. 6, pt. 2, 50 pp.

SOURCES OF INFORMATION

Biographical sketches by J. J. Gilbert and William Churchill in Bull. Am. Geog. Soc., Jan. 1912. R. S. Holway in Univ. of Cal. Chronicle and Official Record, Jan. 1912, and in Science, February 16, 1912. W. W. Campbell in Publications of the Astronomical Society of the Pacific, Feb. 1914. San Francisco Chronicle, San Francisco Examiner and San Francisco Call, December 3, 1911. "Reminiscences of George Davidson" in F. S. Edmonds' "History of the Central High School of Philadelphia," Philadelphia, Lippincott, pp. 74-78. Biannual Reports of the President, University of California 1898-1910. Henry R. Wagner's "George Davidson, Geographer of the Northwest Coast of America" in Quarterly of the California Historical Society, XI, Dec. 1932. Correspondence with Miss Ellinor C. Davidson, 2221 Washington Street, San Francisco; Dr. Alexander McAdie, Hampton, Virginia. Also Davidson's Report on the measurement of the Yolo Base, Yolo County, California. App. No. 8 Coast and Geodetic Survey for 1882.

Augustus Trowbridge

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AUGUSTUS TROWBRIDGE

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BY

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AUGUSTUS TROWBRIDGE

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Throughout history it has been notable when men of means and established position have served as patrons of science or art or social service. It is more notable when such men also devote their own talents and energies directly to useful achievement in such fields. Augustus Trowbridge did not need to earn a salary in order to live comfortably, and so lacked the urgent financial incentive for getting ahead which is necessarily of real power in the lives of most professional men. With his quick wit and unusual social gifts the life of a gentleman sportsman or dilettante could have been delightfully easy to a man of lesser character. But his ideals and self discipline, directing his unusual natural talents, carried him through a career in which scientific and human interests were blended in a remarkably unified and effective manner. His memory, like his life, will continue to be a stimulating example of the unselfish joy of intellectual life and of social responsibility courageously met.

Augustus Trowbridge was born in Brooklyn, New York, on January 2, 1870, the son of George Alfred Trowbridge. His father, born in New Haven of old New England parentage, was a man of vigorous constitution and genial social gifts, a merchant by profession and by avocation an enthusiastic sportsman particularly devoted to riding and hunting. Unfortunately, however, the father's health gave way at about the time of the birth of Augustus, so that the boy was more than usually thrown on the care of his mother and older brothers and a sister. A glimpse of this influence is suggested in his inaugural dissertation for the degree of doctor of philosophy from the University of Berlin, which is dedicated by its author "to his dear mother, in love and gratitude." His mother, Cornelia Polhemus Robertson, was born in New York in 1836 of old Dutch stock. Like her husband, she was socially talented and

of marked native intelligence, and was well educated for a woman of her generation. Evidence of the early cultural influence of that home, which left so strong a mark on Augustus, is seen also in the subsequent careers of his two brothers: Robertson Trowbridge became a writer of prose and verse, and a collector of books; Frederick Kellogg Trowbridge, his older half brother, was a banker by profession who found joy in collecting rare editions of letters and manuscripts.

In his autobiographical record in the archives of the National Academy of Sciences, Trowbridge mentions the fact that he was ten years younger than his nearest brother and that he had very few playmates of his own age,—a situation which evidently left its impression on his memory and which may have had some part in developing his unusual independence and maturity of judgment. His early schooling took him successively to the public schools, St. Paul's Military Academy, Phillips Andover Academy and to France and Italy in care of tutors just before entering college. He has expressed himself as liking all of these school experiences except the military school, and as being particularly fond of natural science, history and languages, both ancient and modern. At an early age he had acquired that fluent proficiency in French, German, and Italian which were to be so useful to him. He used frequently to remark in later life of his gratitude for this early training in languages which was to open to him so many unusual opportunities for interesting and useful work.

At the age of twenty, Trowbridge entered Columbia University where, like many another promising lad of subsequent fame, he came under the influence of that great personality and scientist, Michael Pupin. He had the usual undergraduate interests of which the most prominent, of an extra-curricular nature, was probably his membership on the varsity crew.

At the advice of Pupin and of Rowland, who was a distant cousin, he withdrew from the University in his junior year to accept an excellent temporary position as a civil engineer for the World's Fair in Chicago and then to go to Berlin to pursue the advanced study of physics, leading, after eight semesters in

residence, to the Ph.D. degree in 1898. It was in this period of early manhood that two influences of profound and lasting import came into Trowbridge's life,—the one personal and the other professional,—his wife and his introduction to that developing branch of physics which continued throughout life to be his principal, though not his only field of special scientific research.

Just before going to Berlin in the fall of 1893, Trowbridge married Sarah Esther Fulton, daughter of the editor and Baptist clergyman, Justin Dewey Fulton of St. Louis, Boston and Brooklyn. Dr. Fulton was intensely interested in education and, through education, in safeguarding the church and country from threatening influences. Undoubtedly from this early home influence, as well as by natural bent, Sarah Fulton brought into the home which she and Augustus Trowbridge were founding a deep religious and altruistic influence. She furthermore was a fair match for him in social gifts. Her queenly beauty, charming tact and never failing good spirits made their home a favorite rendezvous for young and old alike. Her companionship, her pleasure in the success of his scientific work and her real support in his social and professional relationships must have been a great factor in maintaining in him that joy in living and satisfaction in working that were so characteristic.

The period of Trowbridge's study in Germany was one of interesting and fruitful development in physics. Wien and Boltzman had just carried the theory of heat radiation to the point from which the brilliant young Planck was soon to deduce his famous radiation formula and thereby give birth to the quantum theory of radiation,—a theory which at the hands successively of Einstein, Bohr, Sommerfeld, Born, Schroedinger, Heisenberg and Dirac, and many others, was to lay a new foundation for the basic science of mechanics as applied to atomic processes. Drude was just ready to publish his "Lehrbuch der Optik," in which the electromagnetic nature of radiation was used to interpret the optical properties of materials. Paschen was developing powerful methods for investigating the spectrum of radiation, and Rubens was developing a brilliant technique for investigating the optical properties of solid surfaces. Radioactivity, X-rays, and

the electron were all just around the corner, but when Trowbridge went to Berlin, radiation was undoubtedly the subject of greatest interest and most rapid unfolding in physics. It was quite natural, therefore, that he should select this field for his special study and research, and that he should work under Rubens. It was also natural that another brilliant young American in Berlin, Robert W. Wood, should have made the same selection, and that he and Trowbridge should immediately begin a life-long friendship with frequent collaboration. Still another friend and future member of the National Academy of Sciences was in that group under Rubens, Ernest Fox Nichols, whose research was, in some aspects, the antecedent of Trowbridge's.

The scientific results which were embodied in Trowbridge's doctor's thesis, under the subject "The Reflecting Power of Metals," provided experimental knowledge of the reflecting powers of gold, brass, copper, iron, nickel and speculum metals in the infra-red region from 1μ to 15μ. Of interest in showing some of his thoughts on more general philosophical subjects at that time are the five propositions which he stated at the end of his thesis as statements that he could defend, after the German custom:

"1. The proposal of hypotheses in connection with established facts is an important factor for the further development of science.

"2. The $\wp$ and σ functions, introduced by Weierstrass into the theory of elliptic functions, are of great importance for higher mathematics.

"3. The doctrine of inherited ideas, advanced by Locke, is not that taught by Cartesius.

"4. The study of specialized subjects in a foreign university offers an advantage, not to be undervalued, for gaining a general background as well as for arousing a freer and more comprehending mind.

"5. In the study of applied mathematics, it is important to understand clearly the physical significance of every equation."

In his entire career as a teacher he saw to it that his students followed this last precept,—considering departure from it to be almost a breach of scientific personal ethics.

Immediately following this period of training in Berlin, Trowbridge was called to his first teaching position, an instructorship in physics at the University of Michigan, which he held from 1898 to 1900. Here he was associated with Henry Carhart, eminent head of the physics department, and with Karl Eugen Guthe, who had recently come from Germany and who was largely responsible for bringing Michigan to its position of prominence in physics. Trowbridge's interests turned for a time to the field of radio with investigations of the coherer as a detector of electromagnetic waves. At the same time he had his "baptism with fire" in the teaching of elementary physics, for Professor Carhart was forced by illness to give up his work for the time being and Trowbridge took charge of Carhart's big freshman course in physics in addition to the duties for which he had been engaged. It was undoubtedly the brilliant manner in which the young instructor carried this double responsibility that brought him prominently to the attention of the American physics profession.

In the fall of 1900, Trowbridge accepted an invitation to an assistant professorship in mathematical physics at the University of Wisconsin, following his friend R. W. Wood who had just been called from Wisconsin to Johns Hopkins. In the following year came also to Wisconsin, Charles E. Mendenhall, who was also greatly interested in radiation and the optical properties of materials. Between these two men sprang up a close friendship which continued fruitfully throughout their lives, in their personal, scientific and administrative activities. They began there an interesting collaborative investigation of ether drift which was continued even after Trowbridge left Madison for Princeton, and which was terminated only by their quick acceptance of Einstein's general theory of relativity as closing the chapter in this field of experimental investigation.

After three years, Trowbridge was promoted to a full professorship in physics, which post he held for another three years until his appointment at Princeton in the fall of 1906. During his six years at Wisconsin, he continued his experimental and

theoretical investigations on various aspects of phenomena of electromagnetic waves.

During this Wisconsin period, Trowbridge took a leave of absence of several months to study in the laboratory of Professor Righi in Bologna. He had become much interested in the new wireless telegraphy and especially in the action of coherers, to which art Righi was making important contributions. From this contact also came his translation of Righi's treatise on "Modern Theory of Physical Phenomena, Radioactivity, Ions, Electrons".

Trowbridge was called to Princeton at a most interesting period. Under the leadership of Woodrow Wilson, that University was undergoing a new burst of intellectual activity and a remarkable group of scientists was being added to the staff. L. P. Eisenhart, Gilbert Bliss and Oswald Veblen had been made assistant professors of mathematics in the previous year, as had Henry Norris Russell in astronomy and George A. Hulett in physical chemistry, and George Birkhoff was soon to come. Edwin P. Adams, three years previously, had joined the staff in mathematical physics (though he was then actively interested in radioactivity). O. W. Richardson, one of Sir J. J. Thomson's most brilliant pupils, came in the same year with Trowbridge to initiate a great program of research in the new field of electronics. James Jeans came from Cambridge as professor of mathematical physics. It is doubtful if so many brilliant young men destined to fame in the physical sciences have ever been assembled within so short an interval of time, unless it were in the early days of J. J. Thomson at Cambridge.

Furthermore, the great Palmer Physical Laboratory was just then being built at Princeton, to provide those splendid facilities without which Princeton's rapid rise in the field of physics would have been impossible. With Howard McClenahan, who had entered physics via electrical engineering, Trowbridge took a particularly prominent part in planning the equipment of this laboratory; and with Richardson and Adams he shared for many years the supervision of the research by most of the physics students in the Graduate School.

Three other men played a particularly important role in Trowbridge's professional career at Princeton. One was William F. Magie, head of the Department of Physics during the entire period of Trowbridge's service in that department, a thermodynamicist trained by Helmholtz, and a gentleman whose fine personal qualities inspired a remarkable loyalty and co-operation among his younger colleagues. A second was Magie's predecessor, emeritus professor Cyrus Fogg Brackett, a splendid physicist of the old school, with whom Trowbridge collaborated for several years in the construction of optical instruments of high precision. The third was Andrew Fleming West, to whose educational philosophy and plans for a great graduate school Trowbridge and most of his colleagues in physics gave their strong support.

Trowbridge's service at Princeton divides naturally into three periods: from 1906 to the Great War; from the close of the war to his leave for European Directorship of the International Education Board in 1924; and from his return in 1928 to succeed Dean West as Dean of the Graduate School until his death.

During the first Princeton period, 1906-1917, Trowbridge's work in physics centered around three activities: his graduate course in physical optics, given usually as a reading-seminar course following Drude's "Lehrbuch der Optik"; his undergraduate courses in optics and in electricity and magnetism; and his research, both personal and in supervision of a small but able succession of graduate students.* To the latter he was an unusually inspiring teacher, because he worked hand-to-hand and idea-to-idea with his students in the spirit of an elder collaborator in the search for truth rather than as a task-master, director or critic.

Into the research of this period, Trowbridge carried the interests acquired under Rubens in Germany. His program

* *Editor's Note:* Among the graduate students coming under Trowbridge's instruction were: F. C. Brown, A. K. Chapman, A. H. Compton, K. T. Compton, I. B. Crandall, C. J. Davisson, L. A. Turner, O. S. Duffendack, G. P. Harnwell, C. W. Heaps, A. G. Shenstone, H. D. Smyth, K. K. Smith, A. T. Waterman, C. T. Zahn, and others.

was centered around the spectrum of infra-red radiation and the optical properties of metals and crystals in respect to such radiation. He recognized the lack of instruments and methods of sufficient power and accuracy to give the desired data, and so undertook a major program of design of such instruments, with most fruitful results.

Among the instruments thus designed and used were a bolometer of increased sensitivity for detection of infra-red radiation, and a vacuum-infra-red spectrometer for extending spectrum measurements through the regions of air absorption and for investigating the absorption of different gases. But by far the major work was the development of a new type of diffraction grating which has found wide use. This work was begun in collaboration with Professor Brackett and involved the following principal features.

First was required a ruling engine to draw some thousands of fine parallel lines to the inch, accurately spaced and uniform in texture, over several square inches of accurately polished concave mirrors of speculum or other metal. This involved much delicate apparatus and adjustment, but especially a long driving screw of practically perfect accuracy and uniformity of screw threads. Such a screw was produced by a final long period of grinding three screws back and forth against each other. After several years of intensive work, a really good dividing engine was built.

Then came the problem of ruling gratings. Here Trowbridge's interest quickly turned to investigation of the effect of the shape of the grooves, or cross-sectional shape of the ruled lines, on the spectrum produced by the grating. This study involved careful selection and grinding to shape of the diamond points used for ruling, and the testing of the gratings produced by each. From this work was developed a new type of grating, the "echelette," characterized by remarkable power of concentrating the spectral energy into certain regions of the spectrum, which could be predetermined in the construction of the grating by aid of a theory which Trowbridge worked out.

Though some good use of these gratings was made by Trow-

bridge and his pupils, he devoted his main energy to further perfection of the gratings. At the same time he generously loaned his most successful gratings to other laboratories interested in infra-red spectroscopy. Notable among these was the University of Michigan where, under H. M. Randall, a most significant program of infra-red investigations was established largely with aid of these instruments.

During this time the Trowbridge family had quickly become most popular and influential in the Princeton community. They became closely identified with the activities of the Trinity Church. Their beautiful new home on the western outskirts of the town was a center of social interest for children as well as their elders, for the three Trowbridge children were ever leaders in sport and play, as well as in more serious activities.

The boys, George and Cornelius, attended Miss Fine's School, the Hill School and then Princeton University, where they graduated with the degrees of B. A. in 1920 and 1921. In extra-curricular activities, George gained international distinction as a track star, and Cornelius was a member of the soccer team and of the editorial staff of the *Daily Princetonian.* Both boys subsequently attended theological school. George Trowbridge is now rector of All Angels' Church in New York, and Cornelius Trowbridge is canon of St. Paul's Cathedral in Boston.

Katherine Trowbridge graduated from Miss Fine's School and then attended the Shipley School in Bryn Mawr, from which she entered Bryn Mawr College. Family reasons causing her to leave Bryn Mawr after one year, she later attended the New York School of Social Work, being more interested in real life than in the conventional routine of social life. In June of 1917, she was married to George Walbridge Perkins, Jr., of New York.

Then came the entrance of the United States into the world war. There had been set up early in 1917, by order of President Wilson as a measure of national preparedness, the National Research Council under the National Academy of Sciences of which Trowbridge was a recently elected member. On the

outbreak of the war, this National Research Council became the coordinating and recruiting agency through which the scientific men of the country were to make their best contribution to the vast variety of important technical problems suddenly thrust forward with desperate insistence. R. A. Millikan and C. E. Mendenhall were at once commissioned as majors in the U. S. Signal Corps to take the lead in this liaison between the military and naval services on the one side and the scientific personnel and laboratories of the country on the other.

Immediately after the declaration of war, a French Commission, consisting of physicists M. Abraham and C. Fabry, came to the United States to disclose some of the newer applications of science to warfare, among them the location of enemy artillery by "sound ranging" and "flash ranging." The former, particularly, of these services demanded apparatus of high precision and considerable complexity, and an operating personnel with technical training. Because of his knowledge and skill in the matter of apparatus, his unusual administrative ability which was even then notable and his excellent judgment and tact in dealing with men, Trowbridge was nominated to General Squier, by Millikan and Mendenhall, to be the technical director of the American Sound and Flash Ranging Service. So Trowbridge was at once commissioned Major in the Signal Corps and given the job of organizing this important service. The manner in which he carried out this commission was one of the features of America's war record which can be recalled with unqualified satisfaction.

The first move was to study the types of equipment, and two groups were recruited at Princeton University and the Bureau of Standards to build instruments of the four types disclosed by Fabry and Abraham. These were tried out on the artillery at the Sandy Hook Proving Ground, and one of them selected for construction, which was at once begun on a production basis in the shops of the Palmer Laboratory and the Bell Laboratories. Associated with Trowbridge in this early work were H. B. Williams, F. A. Saunders, H. M. Dadourian, K. T. Compton, J. Q. Stewart, and N. R. French,—and an important part in

design and construction was played by the head of the Palmer Laboratory Shop, William Duryea.

As soon as this work was well started, under Captain Williams as second in command, Major Trowbridge went to France on September 9, 1917, and immediately made a study of the flash and sound ranging operations on the French and British fronts. His quality of quick decision and open-mindedness was shown by his early cablegram back to Captain Williams ordering transfer of attention to another one of the original four types of equipment, since he discovered that front-line conditions were relatively less favorable to the type originally selected.

Soon good equipment and personnel for sound ranging began to go from America to France, among the notables in the service being Captain Theodore Lyman. A preliminary training school was established in France in charge of Lieutenants Stewart and French. From this school the men went next through a period of training in active service with the British sound ranging units, and finally to their regular duties with the American Army. The service was organized as a battalion of five companies, and by this time had been transferred to the Engineers Corps, with Trowbridge promoted to be a Lieutenant-Colonel, attached to the General Staff at Chaumont. His immediate superior officer was Colonel Roger G. Alexander, of the regular army.

After most creditable operation, the active work of the sound ranging service came to a close on Armistice Day. Trowbridge was proud to show two records of his organization: one was a table showing that the accuracy of enemy gun locations by his men was about equal to the possible accuracy of counter battery fire,—for example an average error of about thirty yards in locating a concealed gun four miles distant; the other was a photographic record of the sound of gun-fire just before and just after the exact time of the Armistice,—a sudden transformation from the din of battle to peace.

As evidence of the success and value of this war work, the following extract concerning one of the sound ranging sections

is quoted from a letter by a Coast Artillery Officer to a superior in the Army Artillery:

"(The) men were always on the job, never seemed to shirk and accomplished many things which seemed impossible. It is with regard to this section's action in moving warfare that I especially desire to call your attention. (It) followed closely our infantry line and in a very few hours after the line stabilized was functioning with two posts. Since such prompt installations of stations during war of movement is in my opinion rare, I feel called upon to compliment you on the excellence of this section not only in overcoming the difficulties of movement but in the general reliability and accuracy of its reports which at all times were satisfactory. I wish to state that I consider this section the best I have ever seen, French or American."

Official recognition of this work was further given by letters from General John J. Pershing and from Brigadier-General D. E. Nolan. The latter letter is here quoted because of its more intimate detail:

"GENERAL HEADQUARTERS

AMERICAN EXPEDITIONARY FORCES

January 20, 1919.

From: Brig. Gen. D. E. Nolan, A.C. of S., G-2, G.H.Q., A.E.F.
To: Lt. Colonel A. Trowbridge, Engineers, A.E.F.
Subject: Letter of Appreciation.

"1. With your relief from duty under G-2, G.H.Q., A.E.F., I wish to take this opportunity of congratulating you upon the excellent work you have done.

"2. It was indeed fortunate, both for you and the American Army, that you could be engaged on Flash and Sound Ranging work, where your high technical ability and long experience could be utilized to the best advantage. The experiments on equipment conducted by you in the United States, your active participation in the organization and operation of the Sound and Flash Ranging School in the American E. F., and your able and energetic work towards the equipping and operation of sections at the front contributed most materially to the successful operation of the Ranging service.

"3. That this service was successful is attested on all sides, and this success is due in no small way not only to your technical

ability but to your resourcefulness, good judgment, and ability to estimate new situations and to get results.

"4. It has been a pleasure to have you as a member of G-2 for these many months. I thank you most cordially for your loyal assistance and support, and assure you of my continued interest in your future welfare and success.

D. E. Nolan,
Brig. Gen., Gen. Staff
A. C. of S., G-2"

The allied governments also were quick to recognize this significant service, and Trowbridge was given the Distinguished Service Medal of the United States on July 9, 1918; was made Chevalier de l'Ordre National de la Legion d'honneur of France on April 4, 1919; and was made an honorary member of the Distinguished Service Order by King George V on July 18, 1919.

In the midst of this successful active work in France, however, Trowbridge and his family suffered a grievous loss in the death of the lovely and talented daughter, Katherine Trowbridge Perkins, on October 7, 1918, following a particularly sharp attack of the influenza which made such ravages in this country and in Europe during that year.

On his return to civil life early in 1919, Trowbridge began his second period at Princeton, a period marked by a broadened range of responsibilities and a shift in his special scientific interests. But his first major problem was to decide between continuation of his career in teaching and research or acceptance of some one of several invitations to enter other fields, such as university administration. With characteristic grasp of essentials, he made his analysis of the chief weakness of Princeton's work in physics and his recipe for its improvement, and decided to stay in Princeton on condition that he be given opportunity and help to put these improvements into effect. This condition being met, he remained. These improvements were educationally interesting:

Heretofore, no distinction in class work in physics had been made between students who had passed college entrance physics examinations and those who had made no previous study of

the subject. Trowbridge believed that this resulted in holding the most promising students of physics down to a low level of achievement, with resulting loss of opportunities and even of interest. He therefore instituted a special sophomore physics class for students who had passed entrance examinations in the subject with a good grade; he selected a more advanced textbook than had ever before been used with sophomores in Princeton; he himself gave the lectures and he recruited every professor in the department to assist him in handling the recitation sections; he so arranged schedules that every six weeks came a test and a regrading of students up-to-date, with reallocation of the best twenty to the top section, the next best twenty to the second section and so on down to the lowest twenty. Thus every student was thrown with others of comparable abilities, and each group was encouraged to go ahead rapidly and to go into subjects thoroughly, subject only to the limitations of its ability. Never before had Princeton students studied so hard, or the physics staff worked so hard, and the results were most encouraging. There was never a doubt but that this plan marked a decided improvement in the interest and accomplishment of the undergraduates, and its effects were felt all through the higher undergraduate courses and into the graduate work. Trowbridge himself worked unremittingly and with great energy to make this program successful.

At the same time, he entered upon a new phase of research, built largely around applications of the powerful new instruments which had been developed for the sound ranging work during the war. These instruments were (1) a fast acting, multiple-element string galvanometer, (2) an automatic camera for photographing, developing and fixing any continuous record of events, with a time scale, on a roll of photographic tape, (3) sensitive radio-tube amplifying systems. With these, and subsidiary devices, he developed a new method for studying vibrations of automobile crank shafts, and assisted automobile companies in minimizing these vibration troubles. He developed a continuous photographic method of recording and counting

optical interference fringes and applied it to precision measurements of thermal expansion and of refractive index. With Karl T. Compton he made a study of the basic action of cathodes in ordinary high pressure metal arcs.

Probably his most active research dealt with a study of flame speeds and efficiencies of internal combustion engines, as affected by variations in the method of firing the explosive mixture. In this he was ably assisted by William Duryea. He developed a quick acting pressure gauge, which could be used with the string galvanometer and photographic recorder to give a continuous record of the pressure-volume-temperature relations during a cycle of the engine. With aid of this equipment for quick indication of conditions, he carried through a series of studies on the effects of withdrawing the spark-gap into a tube, through which the flame could be shot into the cylinder in such manner as to ignite the explosive mixture more suddenly,—with resulting higher temperatures and efficiencies.

Along with this teaching and research program, it was but natural that Trowbridge should have been called upon extensively for administrative service, both within the University and in such external affairs as the National Research Council and the American Philosophical Society. To these calls he responded generously, and always with that peculiar effectiveness which was possible only because of his unusual background of experience and personal gifts. Perhaps the most important of these duties in Princeton was his work on the discipline committee. This cannot be better described than in the words of his closest friend and colleague, Howard McClenahan, who had become Dean of the College and *ex officio* chairman of the discipline committee:

"As a long time member of the discipline committee he easily showed himself to be the most nearly human member of the Princeton faculty. His inherent sporting qualities made him recognize instantly the difference between boyish pranks, of which he was tolerant but bored, and offenses involving moral obliquity or lack of personal integrity, of which he was wholly intolerant."

The best picture of Trowbridge's broad contacts with organized science is afforded by his active service in the National Research Council during its period of transition from a war-time to a peace-time basis. In its important Division of Physical Sciences he was member-at-large 1919-1922, Vice-Chairman 1919-1920 and Chairman 1920-1921. The latter office involved also the Executive Secretaryship of the National Research Fellowship Board in Physics, Chemistry and Mathematics,—an activity in which he took especial interest and pride. During his secretaryship, the Board expended nearly $42,000 in fellowship awards to ten promising young physicists and nineteen similar young chemists. Among them may be mentioned at least six who have come to highest positions of leadership in research: Gregory Breit, James A. Beattie, George L. Clark, Leonard B. Loeb, Robert S. Mulliken and Henry D. Smyth. It was in the success of such young men, whom he had been able in some way to help, that Trowbridge undoubtedly found his greatest satisfaction.

His other chief work in the National Research Council involved the preparation and publication of a great series of monographs on research, designed in part to assemble and make easily available the scattered scientific developments of the war period, and in part to stimulate to further work in these fields the cooperating scientists in the groups which were assembled to prepare the monographs. Largely under his supervision the following monographs were prepared, and later widely distributed:

Acoustics
Algebraic Numbers
Atomic Structure: Quantum Theory
Celestial Mechanics
Electrodynamics of Moving Media
Luminescence
Mathematical Analysis of Statistics
Orbit Theory
Photoelectric Effects
Physiological Optics
Quantum Theory
Research Methods and Technique

Spectroscopy
Theories of Magnetism
Thermo- and Magneto-Electric Effects
X-Ray Spectra
Ionizing and Radiating Potentials

His remaining National Research Council activities comprised membership on the following committees: Building 1921-34; Cooperation with Research Corporation 1921-24; Electrical Insulation 1921-28; Executive Board 1919-21; Publication of Mathematical Books 1920-22; International Astronomical Unions in Astronomy, Mathematics and Radio-telegraphy 1920-21. Of his work at the National Research Council, its Executive Secretary, Dr. Barrows, writes:

"He (Dr. Trowbridge) was held in very high esteem on account of his sound and broad judgment, his impartial and objective attitude and his generous and sympathetic interests."

As a side-light on Trowbridge's ready wit the following incident is related. There had been a jewel robbery in the Trowbridge's Princeton home, which had given Trowbridge occasion to observe professional detectives in action. Not long afterward, there was an outbreak of thieving of small apparatus, mostly radio equipment, from the Palmer Laboratory research rooms. A local boy of rather rough character was suspected, and several times questioned, but without results. Finally Trowbridge asked to have five minutes alone with the boy, during which time he secured a confession and later return of the stolen property. When asked how he had induced the boy to confess, Trowbridge replied: "You fellows don't talk this boy's language. Last summer I observed that the detectives always talked to a suspect in his own lingo. So I just talked like a dick to the boy and said as gruffly as I could: 'Come on now an' can the guff. Yuh better spill the game. Yuh done it and yuh know yuh done it.' And he came right out with the story."

We come now to the activity which Trowbridge himself undoubtedly felt to be his most important contribution to human welfare through education and science. At the close of the

academic year in 1925 he resigned from Princeton University to accept the directorship of the division of the natural sciences of the International Education Board, which had just been established by the Rockefeller Foundation. Given a hearty "Godspeed" by their host of Princeton friends,—featured among other things by a men's dinner at the Nassau Club which will never be forgotten by those privileged to attend on account of Dean West's Ode to the Modern Caesar Augustus and Trowbridge's graceful and affectionate reply,—Dr. and Mrs. Trowbridge departed for their new home in Paris, with official headquarters at 20 Rue de la Baume. In this work he was later joined by Dr. W. E. Tisdale as assistant director,—a most happy arrangement in view of their previous relationship in the work of the National Research Fellowship Board.

Perhaps the vast scope and significance of this aid to science on an international scale can best be realized through examination of the record of accomplishment by the International Education Board during the period of Trowbridge's administration. Approximately $12,500,000 were granted to educational and research agencies for scientific purposes, $1,011,000 were used to support international fellowships in science, nearly $40,000 were used to promote exchange and travelling professorships in the scientific fields and over a million dollars were spent for studies and educational projects generally. In addition to these items for which Trowbridge had direct responsibility, some fifteen million dollars were appropriated to work in agriculture and the humanities under the jurisdiction of his other colleagues on the Board.

Among the forty-six recipients of grants for scientific purposes the following are notable examples: Institute of Physics and Chemistry in Madrid; Jardin des Plantes in Paris; High Altitude Institute on the Jungfrau in Switzerland; Institutes for Physiology, Theoretical Physics and Physical Chemistry in Copenhagen; Department of Zoology and Comparative Anatomy of University College in London; Mathematical and Physical Institutes in Gottingen; Department of Zoology in University of Edinborough; Biochemical Institute at University of

Stockholm; various grants to University of Paris; Zoological Station in Naples; Norwegian Institute for Cosmical Physics; California Institute of Technology for 200-inch telescope. All of these projects involved careful analysis of needs and opportunities and some of them required extraordinarily difficult and skillful negotiations with governments and other bodies in order to insure reasonable certainty of permanence and future actions in the spirit of the terms under which the grants were made. One of the most important of these projects was the building of a great central library at Cambridge University. Formerly the library facilities were scattered, poorly housed and lacking the convenient services of modern library technique. Trowbridge conceived the project of a central library and engaged in a long and arduous series of negotiations with the authorities. The affair was hampered by the inertia of traditions and by entrenched interests. Finally, as one of his last achievements in his European work, Trowbridge brought the negotiations to a successful conclusion whereby the central library was undertaken jointly through a gift from the International Education Board and funds provided locally, and the building was completed and dedicated after Trowbridge had resigned from the International Education Board.

The great program of international research fellowships in the sciences of biology, chemistry, mathematics and physics had, when Trowbridge retired from this post, involved 469 fellows from 37 countries carrying out their fellowships in 16 countries. In this group is found a remarkable proportion of the young scientists who are now the world leaders in their respective fields. It cannot but involve invidious distinctions to mention some by name and not others; yet the following names will mean much to those who know modern science: W. Heisenberg of the "uncertainty principle"; F. Hund who applied quantum rules to chemical molecules; R. H. Fowler, inspiring leader of modern mathematical physics in Cambridge University; and such men as Andrews, Brode, Catalan, Cleveland, Condon, Dicke, Fermi, Frenkel, Goudsmit, Hartree, von Hippel, Kistiakowsky, Krogman, Landis, Liddell, Laporte, Oldenberg,

Oppenheimer, Richards, Rabi, Robertson, Rossland, Spier and Struik. These men Trowbridge considered his scientific children, and he followed their successes with almost paternal pride.

Concerning this work and "many of the scholars to whom he granted fellowships and who afterwards acquired great distinction," Mrs. Trowbridge has said "I think he would like best of all to have mentioned the names of some of those 'potential geniuses' whom he was first to recognize. His negotiations with regard to the new library at Cambridge, the building of the Mathematical Institute in Paris,—the attempt to bring the different parts of the University of Paris onto one campus by buying the site where the Halles des Vins now stand, the establishment of the first laboratory under the Junta in Madrid, the building of the laboratory in the far north of Norway,—all these and many more which I only remember vaguely, read like a romance and gave him the keenest satisfaction. I think the happiest years of his whole career were those spent in Paris."

The record of Trowbridge's official accomplishments during these three busy years in Europe speaks for itself. It was signalized also by many new honors, such as promotion to "Officier de la Legion d'Honneur" of France and award of the Order of St. Olaf by the King of Norway. Striking evidence of the warm personal affection and respect which he inspired in his European acquaintances is shown in the speeches and letters occasioned by his resignation from the International Education Board in 1928, when its great program of grants-in-aid-of-research had been completed. Since that time, the fellowship program only has been continued, under the able and experienced direction of his junior colleague, Dr. W. E. Tisdale.

With the retirement of Dean Andrew F. West from active service on account of age, the Trustees of Princeton University elected Dr. Trowbridge to be his successor as Dean of the Graduate School. A warm friend of Dean West and in full sympathy with his policies regarding this school, Trowbridge was a natural choice for the position. There was great rejoicing as he and Mrs. Trowbridge took up their residence in Wyman

House, the beautiful official residence of the dean, adjacent to the Graduate College.

Of this third period in Princeton there is little to recount, since the work of the dean went forward with skillful and efficient management and the citations for honorary degrees were models of terse characterization so appreciated by critical commencement audiences. Example, Norman Thomas, Litt. D. 1932:

"Norman Thomas, a graduate of this university in the class of 1905, a brilliant and successful clergyman, son and grandson of ministers of the religion whose earliest disciples held all things in common for the common good, who, for conscience' sake gave up a conventional form of ministry to his fellow men to become the fearless and upright advocate of change in the social order. A vigilant assailant of the corruption and the crime which batten on our complacent civic indifference notably to the conduct of municipal affairs. Irrespective of party preference we join to honor this valiant and distinguished son of Princeton."

Unfortunately the warnings of ill-health began to appear,—a new experience for this man whose activity at work or play had scarcely suffered interruption. Leave of absence failed to halt the encroachment, so that his resignation was regretfully accepted by the Board of Trustees in the spring of 1932. In so doing they adopted the following resolution:

"The Trustees cannot allow the retirement, because of continued ill health, of Augustus Trowbridge as Dean of the Graduate School to take place without giving expression to their high appreciation of his exceptional ability as a teacher, his outstanding position as a scientist, and his unfailing efficiency as an executive. In every task assigned him throughout his distinguished career, his sincerity of purpose in its undertaking and his enthusiasm in its performance have made him eminently successful in what he has accomplished, while his charm of personality has endeared him to all—students and colleagues alike—who have come in contact with him.

"Returning to Princeton in 1928, he gave four years of notable service as Dean of the Graduate School. In that position

he displayed high administrative ability in handling the many difficult problems assigned to him, and maintained without impairment the high standards that had been established under Dean West. A notable addition to the excellence of his administration was to be found in the delightful hospitality of Mrs. Trowbridge and himself, which distinctly added to the advantages of residence in the Graduate College.

"In teaching, in research and in administration he leaves behind him a high record, and his active presence on our campus will be sorely missed."

For nearly two years following his resignation, Trowbridge made a courageous effort to maintain his health. He spent the summers with his family at their summer home at Hancock Point, Maine. He put his records and papers in order. His cheerfulness and good sportsmanship never failed him,—they were too deeply rooted in his character. In the winter of 1934, seeking the beneficial climate of the Riviera which he so loved, he and Mrs. Trowbridge left on his last journey. After a happy winter, death overtook him quite suddenly on March 14, 1934, as he and Mrs. Trowbridge were together in Taormina, Sicily.

After a most impressive funeral service in the beautiful new chapel of Princeton University, he was buried in the Princeton cemetery on March 29, 1934.

There can be no more fitting close to this all too inadequate record of the life and work of one of the noblemen of science than the prayer offered by his friend Dean Wicks at Dr. Trowbridge's funeral:

"O God we stand in reverence and awe before the unseen source of more than we could ask or think, in debt for all rare lives gifted to embrace what lies beyond our ken and able to make vivid that to which we might aspire.

"We would remember before Thee and for our good, one who lived to be real, above all false sentiment and cant, and by his fruits rather than by words proved his nearness to the Great Reality; who with faithfulness in work given him to do, and with refined taste that put the cheap and crude to shame, ever kept himself responsive to an excellence beyond the requirements of men; who was guided by the inclination of love to find needs where no rules could prescribe; who let no narrow

zeal blind him to the wider ranges of a cultured life, and made himself a counsellor and friend in many lands to those who sought to keep alive, in a shattered world, the interests of the mind and spirit; and whose sympathy and humor and inner resource made his companionship a blessing, especially at home, and enabled him through sorrow and ill health to fight the good fight to the end, living his life for the things that abide. Amen."

BIBLIOGRAPHY OF SCIENTIFIC PAPERS BY AUGUSTUS TROWBRIDGE

1897

Dispersion und absorption der ultrarothen strahlen in steinsalz und sylvin (in collaboration with H. Rubens). Ann. der Physik (3) 60: 724-739.

1898

Dispersion des sylvins und reflexionsvermögen der metalle. Ann. der Physik (3) 65: 595-620.

1899

Quantitative investigation of the coherer. Amer. Jour. Sci. (4) 8: 199-205.

1900

Theory of the coherer (in collaboration with K. Guthe). Phys. Rev. 11: 22-39.

1901

Form of artificial submarine cable. Phys. Rev. 12: 359-362.

1903

Influenza delle onde elettromagnetiche e reazione del circuito sul getto a Hg di Lippmann (in collaboration with L. Amaduzzi). Nuovo Cimento (5) 5: 322-325.

Un nuovo relais. Nuovo Cimento (5) 5: 267-272.

1904

Determination of coefficients of mutual induction. Phys. Rev. 18: 184-186.

Translation of: Righi, Augusto. Modern theory of physical phenomena, radioactivity, ions, electrons. Macmillan, 1904. 165pp.

1905

Differential transformer. Phys. Rev. 20: 65-76.

1906

Note on comparison of capacities (in collaboration with A. H. Taylor). Phys. Rev. 23: 475-488.

1908

Bemerkung zur abhandlung von F. Paschen betreffend der dispersion des steinsalzes und sylvins im ultrarot. Ann. der Physik (4) 27: 231.

Optical properties of collodion and celluloid. Phys. Rev. 27: 282-285.

1910

Reflecting power of ice in the extreme infra-red spectrum (in collaboration with J. Spence). Phys. Rev. 31: 61-67.

The ether drift. Amer. Phil. Soc. Proc. 49: 52-56.

A vacuum spectrometer. Phil. Mag. (6) 20: 768-770.

Groove-form and energy distribution of diffraction gratings. I. (in collaboration with R. W. Wood). Phil. Mag. (6) 20: 886-898.

Infra-red investigations with the echelette grating (in collaboration with R. W. Wood). Phil. Mag. (6) 20: 898-901.

Gestalt der ritzen und verteiligung der energie bei beugungsgittern (in collaboration with R. W. Wood). Phys. Zeits. 11: 1161-1168.

Ultrarote untersuchung mit der echelette (in collaboration with R. W. Wood). Phys. Zeits. 11: 1114-1115.

Konstruktion eines vakuum-spektrometers (in collaboration with E. Keil). Zeits. f. Instrum. Kunde 30: 334-338.

1911

Groove-form and energy distribution of diffraction gratings (in collaboration with I. B. Crandall). Phil. Mag. (6) 22: 534-547.

Concerning the echelette grating. Astrophys. Jour. 34: 317-319.

1912

Simple demonstration apparatus for the infra-red spectrum. Science, n. s. 35: 931-933.

1913

Thermal conductivity of air at low pressures. Phys. Rev. (2) 2: 58-64.

1916

The echelette grating. Phys. Rev. (2) 8: 485-499.

1919

Sound and flash ranging. Science, n. s. 49: 521-523.

1920

Sound ranging. Franklin Inst. Jour. 189: 133-146.

Augusto Righi. Science, n. s. 52: 122-123.

X-rays and atomic structure. Sci. Amer. Monthly 2: 357-360.

1922

Photography of moving interference fringes. Opt. Soc. Amer. Jour. 6: 195-198.

High-speed photography of vibrations. Franklin Inst. Jour. 194: 713-729.

1923

Brauer's theory of the function of the cathode in electric arcs (in collaboration with K. T. Compton). Opt. Soc. Amer. Jour. 7: 321-325.

1924

String galvanometer oscillograph with automatic photography. Opt. Soc. Amer. Jour. 9: 557-568.

Spectroscopy in the infra-red region. Franklin Inst. Jour. 199: 343-352.

Ernest Fox Nichols. Science, n. s. 59: 415-416.

Last Biographical Sketch in

WHO'S WHO IN AMERICA

1932-1933

TROWBRIDGE, Augustus, physicist; b. New York, Jan. 2, 1870; s. George Alfred and Cornelia Polhemus (Robertson) T.; Phillips Acad., 1886-87; Columbia U., 1890-93, D. Sc., 1929; A. M., Ph.D., U. of Berlin, 1898; m. Sarah Esther Fulton, of New York, Sept. 20, 1893. Instr. physics, U. of Mich., 1898-1900; asst. prof. physics, 1900-03, prof. 1903-06, U. of Wis.; later prof. physics, Princeton Univ.; dean of Grad. Sch. Princeton since 1928. Mem. International Congress Applied Chemistry, Berlin, 1903; sec. Physics Sect., Internat. Congress Arts and Sciences, St. Louis, 1904. Trustee Princeton University Press. Commd. Maj., Engr. R. C., 1917; intelligence dept., attached to Gen. Pershing's staff at hdqrs. A.E.F. in France; lt. col., 1918; discharged, 1919. D.S.M. and D.S.O.; Officer Legion of Honor (France); Knight of Order of St. Olav (Norway). Republican. Member National Acad. Sciences (chmn. div. physics, 1921); chmn. div. physical sciences and member research fellowship bd., Nat. Research Council, 1920-21, and mem. research fellowship bd. in physics and chemistry, 1920-25; European dir. for Science, Internat. Edn. Bd.; fellow A.A.A.S.; mem. Am. Philos. Soc., Am. Phys. Soc., Washington Acad. Sciences, Delta Phi. Address: Princeton, N. J.

Geo. J. Huntington

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BIOGRAPHICAL MEMOIR

OF

GEORGE SUMNER HUNTINGTON

1861–1927

BY

ALEŠ HRDLIČKA

PRESENTED TO THE ACADEMY AT THE ANNUAL MEETING, 1937

Preface

While I was a member of the Pathological Institute of the State Hospitals I was introduced in 1897 to Professor George S. Huntington, with the object of studying the collection of human bones, which I was informed was being made in his museum. He received me very kindly in his laboratory, took me down to the basement where a large room facing 59th Street and the Roosevelt Hospital was nearly filled with all sorts of boxes and cases containing bones, and here I was let loose on the then precious, tagged, but otherwise unkempt accumulation. Here in this basement room, the tall windows of which had never been washed, I spent a good and happy part of my time when in the city until my departure for Washington in 1903, examining, arranging and supplementing the collection with its important yearly accretions. I saw Professor Huntington whenever I had a need of him, without abusing the privilege. He was invariably friendly and helpful and there gradually developed between us a quiet unassuming friendship which, as long as we saw each other, at least two or three times a year until his illness, was never marred by the slightest shadow.

During all those years I had free access not only to the bone collection but also to all parts of the museum and laboratory, which gave me a chance to become well acquainted with most of the collections, as well as Huntington himself and his own work. I acquired a cordial esteem of him and was always glad of a chance to see him, be greeted with his cheerful smile, and find him understanding and helpful. One of my deep regrets is that I never saw him again after ill health obliged him to leave the college.

It was because of my long association with Professor Huntington and my gratefulness to him, but above all because of my esteem of his devotion to scientific work and of his wholly unselfish and high character, that I was happy to accept the assignment to prepare his biography for the National Academy of Sciences. Regrettably it will not be possible to do full justice to the task. Though a number of biographic notes of

Huntington were written soon after his death,[1] above all the excellent ones of Professor McClure, a large part of what concerned his life as a man and even his illness and death, is missing, and what is worse, not now adequately obtainable. He himself left no autobiographic notes, there is no account of his intimate life, nor any surviving life-long friend who might remember, and the still living members of his family know comparatively little about it. Even the details of his illness and end have not been and can no longer be properly recorded.

In preparing this memoir I shall draw, with his permission, copiously on Professor McClure's very good presentation. I am indebted for valuable details, foremost to Mrs. Ann H. O'Donnell, the oldest daughter of Professor Huntington, and to Mr. Martin Petersen, the able illustrator of his works and his aid in many matters in the laboratory and museum. I wish to thank also Dr. Samuel W. Lambert, of New York City, for additional notes regarding Dr. Huntington's last illness; Dr. Ellsworth Eliot, of the same city, for his personal reminiscences; Drs. William K. Gregory of the American Museum of Natural History, New York; Frederick Tilney of the Neurological Institute of Columbia University; Henry H. Donaldson of the Wistar Institute, Philadelphia; Frederick T. van Beuren, Jr., College of Physicians and Surgeons; and William Darrach of New York City, for additional valuable aid. I am also grateful to William E. Huntington, at present of Washington, D. C., for his endeavors to be helpful; and last but not least to Dr.

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[1] McClure (C. F. W.) George Sumner Huntington: An Appreciation. Am. Jour. Anat., Vol. XXXIX, No. 3, July 15, 1927, pp. 355-377.

McClure (C. F. W.) George Sumner Huntington: Anatomist. An address delivered before the New York Academy of Medicine on January 20, 1928. Science, March 23, 1928, LXVII, No. 1734, pp. 301-307.

McClure (C. F. W.) Life and Work of George S. Huntington. Bull. N Y. Acad. Med., Vol. IV, February 1928, pp. 250-265.

Lambert (Samuel W.) Life and Work of George S. Huntington. Bull. N. Y. Acad. Med., Vol. IV, February 1928, pp. 250-265. Discussion following presentation of paper by C. F. W. McClure.

Tilney (Frederick) An Appreciation of Dr. George S. Huntington. Bull. N. Y. Acad. Med., Vol. IV, February 1928, pp. 254-260.

Obituary note. Med. Jour. and Rec., N. Y., 125:277, February 16, 1927.

Charles B. Davenport, of Cold Spring Harbor, Long Island, who assisted me effectively wherever it was possible.

I shall not attempt to go deeply into the more remote genealogy of the Huntington and Sumner families, those of Dr. Huntington's derivation. Such matters are difficult of satisfactory treatment, and what is known has been covered adequately by the Huntington and Sumner family genealogies,[2] and by Dr. McClure in his two commemorative articles.

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[2] Huntington, E. B. 1863. A genealogical memoir of the Huntington family in this country, embracing all the known descendants of Simon and Margaret Huntington.

Appleton, William Sumner. 1879. Records of the descendants of William Sumner of Dorchester, Massachusetts.

GEORGE SUMNER HUNTINGTON

1861–1927

BY ALEŠ HRDLIČKA

George Sumner Huntington, elected to the National Academy of Sciences in 1924, died January 5, 1927, at the age of sixty-six years less two months, after a prolonged illness, induced by repeated cerebral embolism.

George S. Huntington—as he signed himself—was born in Hartford, Connecticut, March 21, 1861. He was the son of Hezekiah Huntington, Jr., and of Katharine B. Sumner, both descended from old American stocks of distinction. At the time of George's birth Hezekiah was sixty-six years old, his second wife, George's mother, being in her thirties. There were two children of this union, the first a daughter, Katharine Sumner,[3] and George. The father died not long after the birth of the son.

His father, initially a publisher and business man, was eventually president of the Hartford Fire Insurance Company; his mother was the daughter of a Hartford physician. Both the parents were derived from old American family lines, various members of which reached eminent positions. His grandfather on his father's side was a lawyer of note.[4] On the Huntington side the Puritan American ancestry of the family reaches to 1633, that on the Sumner side to 1636. The Huntingtons were essentially Connecticut people, the Sumners were from Massachusetts and Connecticut. Both families furnished numerous public servants, judges, churchmen, businessmen, soldiers, lawyers, and doctors. There were, interestingly, no artists nor musicians; and no literary men, philosophers, nor men of science, with the exception of George Sumner, the maternal grandfather of George S. Huntington, who showed marked mathematical

[3] The sister was but a year or two older; she died in recent years.

[4] For details on the two families see McClure (C. F. W.)—George Sumner Huntington: An Appreciation. Am. Jour. Anat., Vol. XXXIX, No. 3, July 15, 1927, 355 et seq.

abilities, graduated in medicine, and is said to have become eventually professor of botany at Trinity College.

To quote from Dr. McClure:[5]

"the descendants of Simon Huntington, the Puritan emigrant, have been well represented in all the industrial, educational, military, civil, and religious movements of the American continent for more than two centuries. . . . There have been two governors of states, and at least fifteen judges of county courts, superior judges, federal or chief justices. Nearly one hundred members of the family have been college graduates. . . . Ministers have exceeded one-third of the college list, and lawyers and doctors have equaled nearly a third each."

On the Sumner side, there were a large number of prominent men in public service and in the Army, including one governor and a general, with numerous deacons.

Surely a rare and honorable hereditary background, but one also very interesting genetically, for while it presents on both sides of the family an unusually similar record of public servants, administrators, soldiers, lawyers, doctors and churchmen, it eventually results in the appearance of an outstanding example of a man almost withdrawn from the world and devoted to scientific research.

PERSONAL LIFE AND FAMILY

Little is known definitely about George Sumner Huntington's childhood. It evidently was spent in Hartford, Connecticut, and offered nothing unusual. After the death of his father, his mother, for some reason took the ten-year-old boy to Germany, and for six years George was given instruction in German and attended German schools. They returned in 1877 and that same year the young man, so nearly Germanized that he spoke English with an accent and, according to Dr. Eliot, greeted male friends with kisses, entered Trinity College at Hartford. However, he soon became re-Americanized, though throughout his career in writing he was occasionally liable to transpose a

[5] McClure (C. F. W.) George Sumner Huntington: An Appreciation. Am. J. Anat., 1927, XXXIX, 355 et seq.

word in German style. At Trinity he soon became a member of Alpha Delta Phi and was well liked by his class mates.

Information about his private life during these and the next few years is very meager. On June 18, 1885, a year after his graduation in medicine, he married Annie McNair Elderkin, a daughter of Col. William A. Elderkin, at one time a professor of Spanish and mathematics at West Point, and Fanny Gurley, daughter of the Rev. Phineas D. Gurley, who was President Lincoln's pastor.

Four daughters were born of this union. The oldest, Ann H., a highly intelligent and sensitive woman, graduated from Barnard College in 1910, and from 1913 to 1918 acted as assistant librarian in the library of the Medical Society of the County of Kings, Brooklyn. Before her marriage she made abstracts in the Army Medical Library, Washington, D. C. She is married to John Joseph O'Donnell, an employee of the Washington Navy Yard. They have three sons.

The second daughter, Katharine Sumner, has not married. She graduated from the School for Nurses of Roosevelt Hospital, New York City; is now retired from active work and makes her home in Hollywood, California.

The third daughter, Frances Gurley, graduated from the Presbyterian School for Nurses in New York City. She married Louis LeBouvier, an officer in the British Army during the World War, by whom she had two sons. Later she married Samuel Ades, a British coal merchant. She now resides in Chelsea, London, and operates an exclusive little night club.

The fourth daughter, Elizabeth Putnam, was killed in a train-auto collision on May 11, 1928, mid-way between Denver and Colorado Springs. She had written a novel before the time of her death, and was collecting material for another. The book, "The Son of Dr. Tradusac," was published after her death. She also wrote a little volume of verse entitled "The Playground of the Gods." She worked at the New York Orthopedic Hospital for some time.

The three last mentioned daughters served in the U. S. Army during the World War, the two older ones as nurses, the young-

est as a "reconstruction aide." All three apparently inherited their father's love for and interest in medicine.

In 1908 Dr. Huntington, after a blighting divorce, married Alice Ashley Kidd of Tivoli, New York, the widow of one of his friends, Dr. Churchill Carmalt. She was fifteen years his junior, and they had no children. The union was happy and she attended G. S. H. devotedly throughout the years of his illness. She still lives in Charleston, N. C.

EDUCATION, CAREER

The elementary education of G. S. H. consisted of courses in the public schools of Hartford, and of preparatory courses with eventual attendance in a gymnasium (details wanting) in Germany.

On his return from Germany he read and spoke German, and read Latin and some Greek. In the fall of 1877 he entered Trinity College and took courses more especially in zoology, chemistry, English, German, Latin and Greek. He was graduated with the degree of Bachelor of Arts, receiving honors in mental, moral and political philosophy, in chemistry, and in natural sciences. In his senior year he received the Chemical Prize for his essay on explosives. At his graduation from Trinity College he ranked seventh in a class of nineteen.

In the same year (1881) Huntington matriculated in the College of Physicians and Surgeons, New York, at that time located on 23rd Street and Fourth Avenue. His preceptor was Dr. Henry B. Sands, a prominent surgeon, and Huntington's intention at this time was to become a surgeon. Dr. Samuel W. Lambert, his fellow scholar and friend, states "we both believed we were started on a surgical career." In 1882, according to Dr. Lambert, medical instruction at the College was given entirely by lectures, either theoretical or clinical. Evidence of attendance was given only by the purchase of cards for the theoretical lectures and for anatomical material. George Huntington bought his real education, like many more of us, outside or inside the College walls, by paying the younger hospital, dispensary and laboratory physicians for private courses.

The length of the medical course at that time was three years and Huntington graduated with the degree of M.D. in 1884. This time he ranked second in a class of 125. In a competitive examination known as the Harsen Prize Examination, taken by the first ten men in the graduating class, he won the first prize of five hundred dollars. He won also a prize for the best clinical reports at the New York Hospital, and Trinity College conferred on him the honorary degree of A.M. After his graduation Dr. Huntington became an assistant in surgery to his preceptor, Dr. Sands. He was also appointed an interne on the surgical staff of the Roosevelt Hospital, which position he held until 1886.

In 1886 Dr. Huntington was made assistant demonstrator of anatomy at the College of Physicians and Surgeons, under Prof. Sabine. He also acted as a junior assisting surgeon at the Roosevelt Hospital and as a visiting surgeon to the Bellevue Hospital; and conducted a private quiz class in anatomy.

In 1887 the College moved to its new quarters in West 59th Street, and Huntington, in addition to his post in anatomy, was made the first chief of clinic in the surgical department of the Vanderbilt Clinic.

In 1889 Professor Sabine was obliged to withdraw from the anatomical department at the College, dying shortly after; and following a series of "competitive lectures" between Drs. Huntington and Gallaudet, the former in 1889 withdrew from his surgical activities and was appointed to the vacancy as a full professor of anatomy—the first full-time position of the nature in this country. This position he filled for the 35 years following, until obliged through illness to relinquish it in 1925.

Between 1889 and 1895 much of the history of Huntington's Department of Anatomy is lost. It was a period of laying substantial foundations both for the department and for a museum, which soon bore important fruit, as will be seen later.

In 1898 Huntington became the American editor of the (British) Journal of Anatomy and Physiology, in 1899 editor of the Anatomical Memoirs, in 1900 associate editor of the American Journal of Anatomy; from 1899 to 1903 he was the President of the American Association of Anatomists. In 1904 Professor

Huntington received the honorary degree of Sc.D. from Columbia University, in 1907 an honorary LL.D. from Jefferson Medical College; and on April 30, 1924, was elected a member of the National Academy of Sciences.

TEACHING

Dr. Huntington was not a public nor a popular lecturer; but he developed into a great teacher of anatomy. He changed anatomical teaching from didactic to essentially demonstrative; and he widened its scope by comparative anatomy. As time went on he became more and more engrossed with the developmental aspects of different parts, and his instruction was colored correspondingly. He gradually changed from a merely "practical" to a scientific anatomist, the foremost pioneer in that respect in this country. But his lectures were not "easy."

To give a fuller picture of the subject I will quote from letters and writings of some of Dr. Huntington's associates or collaborators.

"Huntington's conduct of the chair of anatomy was peculiar in that he devoted a large part of the course to comparative morphology and its application to the human subject. Students failed to acquire a 'working knowledge' of anatomy. The lectures were over their heads and were more adapted to the postgraduate specialist and to research workers. The students nevertheless admired and respected him greatly. To them he was 'George S.'" (Letter from Dr. Ellsworth Eliot, October, 1936.)

"As a teacher Dr. Huntington was extraordinarily stimulating to the students who were really interested in their work. He was always willing to help such men, but took no interest whatever in the dullards. He did practically no teaching among the students except to lecture and demonstrate, the dissecting room instruction being carried on by his assistants. Occasionally he gathered his assistants together and gave them most illuminating informal talks in his own museum on the development of various organs, illustrated by specimens taken from comparative anatomy." (Letter from Doctor Frederick T. van Beuren, Jr., June 2, 1936.)

"Nothing impressed me more than his peculiar method of teaching. This was as singular as it was individualistic, and quite as distinctive as the atmosphere of his laboratory. If there

was one thing that distinguished the instruction which he gave me, it was its superb detachment, its masterly distance. Days went by, weeks passed, and further than the formal daily salutation, he never spoke to me or gave me the slightest attention. Then came a day, a rare day indeed, when he sat beside me for nearly a whole morning. After he had gone I felt inspired anew. I was conscious of a fresh zeal and determination, with something like a glow of enthusiasm even for the, to me, distantly related genito-urinary system of the domestic cat. Consciously or unconsciously, he had given me a new idea about teaching. He had clearly shown what is all too little understood by those who have the responsibility of medical instruction. Obviously, the chief purpose here is to inspire the student with the desire to learn, to provide every opportunity for such learning, and to eliminate in so far as possible all the processes of formal indoctrination. For the real joy of learning comes of that sense of independent acquisition, that realization of possessing a self-gained knowledge. This most effective teaching was not by words but by work. That superb detachment already mentioned he carried into his formal instruction and lecturing as well. He spread before his students a feast fit for the gods and it was no fault of his when perchance the gods had gone a-hunting in other fields than medicine, and none but minor deities came to his table. These considerations affected him not at all. Regardless of his auditors, he set forth in that splendid diction of which he was a master, the full content of his facts in all their details and relations. Each one of his lectures was prepared with meticulous care. The morning hours before them were spent in his library in concentrated study of the subject he was to present and all of the drawings employed to illustrate his points, he practiced beforehand in fullest detail." (Tilney (Frederick)—An Appreciation of Dr. George S. Huntington. Bull. N. Y. Acad. Med., second series, 1928, Vol. IV, pp. 254-260.)

To which should be added the very fitting account of Professor McClure:[6]

"Until the time of the appointment of Doctor Huntington, in 1889, as full-time professor, anatomical teaching in the College of Physicians and Surgeons consisted of three didactic lectures a week given to large classes; there was no regular provision made in the program for the systematic and regular dissection

[6] McClure (C. F. W.) George Sumner Huntington: An Appreciation. Am. Jour. Anat., Vol. XXXIX, No. 3, July 15, 1927, pp. 355-377.

of the human body. In other institutions of the same type the instruction in anatomy was scarcely better. There were two important changes which Doctor Huntington at once initiated. The first was the introduction of the laboratory method of teaching human anatomy to small sections. The second was his method of presentation; this was the application of the morphological method as a means of interpreting the structure of the human body . . . this last arose from his constantly broadening conception of the field of anatomy.

"While he was developing his new anatomical course at Columbia . . . it became more and more evident to him that the multitudinous detail which the structure of a highly specialized vertebrate such as man offers is very confusing to the students. It was then that he adopted the morphological method as a means of interpreting the human body, and in doing this he was instrumental in influencing the whole future of anatomical study in the medical schools in America by giving new importance to comparative anatomy, and so vitalizing the whole subject. There had been other comparative anatomists in America; Huntington was the first man in this country with the vision to see the importance of emphasizing the comparative method in the study of human anatomy, and to make clear the fact that the vast detail in the human organism has no significance unless this is interpreted from the standpoint of the morphology of the different systems, and in relation to the application of structure to function. The significance and importance of the structural peculiarities of man he accentuated and illustrated by comparison with the morphology of corresponding structures in the lower vertebrates. From the outset this new method of presenting the subject arrested the attention of his students and aroused in them a keener interest. What had before seemed to them a mere mass of disconnected details to be laboriously memorized now took on form under the scientific analysis and interpretation given them by Doctor Huntington."

Finally we have a few words on the subject by Huntington himself. In a paper on "Modern Problems of Evolution, Variation and Inheritance in the Anatomical Part of the Medical Curriculum," published in the American Journal of Medical Sciences, December 1898, p. 3, he says:

"I vividly recall my own student days, and I cannot but sympathize with the feeling, more or less akin to despair, with which many students begin to apply themselves to the minute details of structure taught in human anatomy. It seems to me

that it is wise to compare our system of instruction with that usually adopted in some other branches of scientific and mechanical education. It would be universally acknowledged a wrong course of procedure if a student of mechanical engineering were taught the constructive details of a modern locomotive, or of the quadruple expansion engines of an ocean steamer, before he had been offered the opportunity of examining and studying the simple piston, cylinder, or boiler; or if a course in electricity commenced with the dynamo, before taking up the magnet. And yet I believe that in many respects we err in the same direction if we place before our students the multitudinous details which the structure of a highly developed and specialized vertebrate like man offers, without availing ourselves of the advantages which the comparison with simpler and more evident forms possess both in respect to morphology and the physiological application of structure to function."

"Such," to use the words of Doctor McClure, "were the new methods in the teaching and general conceptions of anatomy which were initiated by Doctor Huntington in 1889, and were consistently followed and developed by him during the thirty-five years that he was professor of anatomy in the College of Physicians and Surgeons."

To the above I may add a few minor personal recollections. Professor Huntington's lectures were generally given in the latter part of the forenoon. The hours before each lecture were given exclusively to his preparation for the same and no one dared approach him during this time. He used no notes and few charts, but ample extemporaneous drawings. In the amphitheater in which he lectured were tables for specimens and a due supply of these was brought in for each lecture. There was a large supply of them in a big room in the cellar of the anatomy building, opposite the bone room. The lectures were thoroughly erudite and for that reason perhaps more instructive than merely enjoyable. Their object was a broad, materially documented understanding of the subject, rather than simple information. No undergraduates were permitted, for good reasons, in the laboratory or museum. The dissecting room work was wholly in charge of prosectors. A small menagerie of dogs, cats and other animals, including an old turtle, was kept for study and teaching purposes.

The Huntington method found before long an enthusiastic follower in Franklin P. Mall, professor of anatomy at Johns Hopkins, and the two men, Huntington and Mall, brought about a revolution in the teaching of anatomy in this country; which revolution, unfortunately, has been and is still being carried to excess, on the animal side, by some of their followers. Certainly neither Huntington nor Mall could have foreseen, or desired to see, human anatomy fall more or less into neglect because of the very comparative studies that were to enrich and help its further development.

SCIENTIFIC WORK

From the very beginning of his professorship in anatomy, Huntington engaged in scientific research, and to this he devoted all of his time outside of teaching requisites, not only in his laboratory, but to an increasing extent, as time went on, even in his home.

His work in this line was in the main that of dissection, observation with the microscope, and reconstruction in wax of sections. He became very expert with injections, and with the preparation of organs or parts for the museum or for instruction. He amassed a large and valuable personal library in anatomy and biology, but his main interests and endeavors were in original work. He did not go into experimental work on the animals of his "menagerie" but used these only for dissections and preparations; their skeletons being then cleaned and added to the collections.

He always had some collaborators in his laboratory, but these were generally independent scientific workers, each carrying on a research in his own line, mostly without Huntington's assignments, interference, or even visible supervision; but he knew well what was going on, and when consulted was invariably helpful with advice, and a worthwhile work had in him always a generous and helpful backer.

His writing must have been done mainly at home, for at the College he never had a stenographer. He had a typewriter in

his office which, on the rare occasions when he felt he *had* to use it, he manipulated with one finger. His scientific work was always unruffled, sustained, and methodical. He had a valuable helper with all the illustrations, and also in many other respects, in Martin Petersen.

There were never any scientific assistants in the strict sense of the word, though now and then there was a co-worker in some line. The principal of such co-workers was eventually Professor McClure of Princeton. The list of other research men who in the course of time were associated with Dr. Huntington is a long one. An incomplete list includes Hugh Auchincloss, Joseph A. Blake, Dr. Brown, Churchill Carmalt, George Draper, Adolph Elwyn, K. Frantz, Bern B. Gallaudet, A. Hrdlička, Adrian Lambert, Samuel W. Lambert, Eugene Pool, Herman von W. Schulte, Anthony Spitzka, Jr., Fordyce St. John, Oliver S. Strong, Frederick Tilney, Frederick T. van Beuren, Jr., Allen Whipple, and many others.

It will be useful to give here the expressions on this subject of some of the surviving Huntington associates.

Dr. Ellsworth Eliot:

"Dr. Huntington's knowledge of comparative anatomy was most extensive . . . He was greatly interested in all variations which could be demonstrated in the course of human dissection." (Letter to A. H., October 1936.)

Dr. O. S. Strong:

"He was one of those men who simply lived in the laboratory, and I believe he had a more intimate first-hand knowledge of vertebrate anatomy than any living man. Perhaps his major interest along these lines was in the internal organs, next muscles and bones, and last the nervous system. He had a museum filled with beautiful dissections of vertebrates and corrosions of the bronchial tree, etc. Later he developed the work in his department along embryological lines and published researches along these lines, especially in the development of the blood and lymph vascular systems." (Letter May 16, 1936.)

Dr. William K. Gregory:

"Although the great mass of Prof. Huntington's work was outside my special field, as it dealt with various parts of the soft

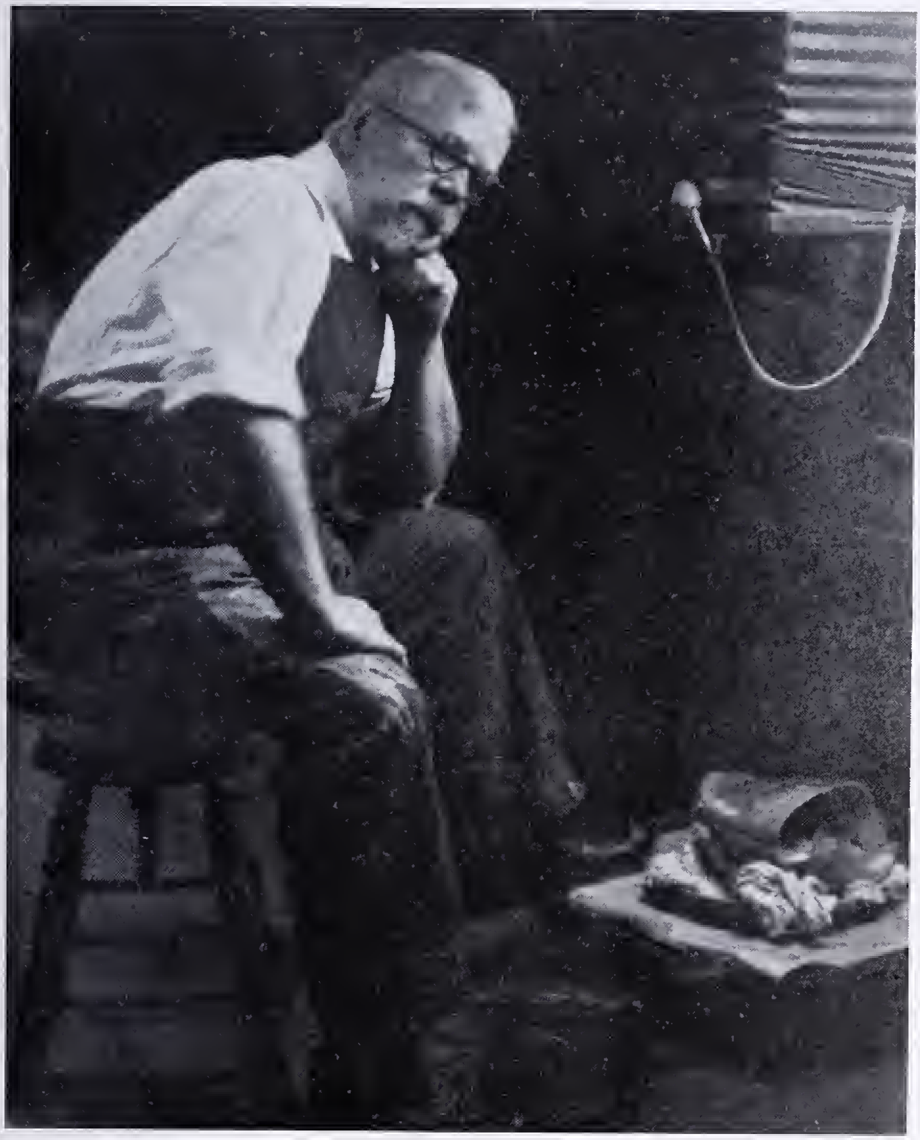
anatomy rather than with the skeleton, I can not refrain from admiring the constructive character of his work on the evolution of the eparterial bronchus of mammals, of the comparative anatomy of the ileo-colic region, on the evolution of the salivary glands, of the lympathic system, and others. His 'Modern Problems of Evolution, Variation, and Inheritance, in the Anatomical Part of the Medical Curriculum,' is in its way a masterpiece. In estimating the achievements of Prof. Huntington it should be remembered that his greatest work, a monograph on the evolution of the pulmonary system of vertebrates, has never been published, but that it is represented by an extensive series of lithographic stones which were made by his artist, Mr. Petersen, over a period of many years. It is deeply to be regretted that no one has undertaken to publish these plates with appropriate legends. In connection with his shorter papers on the subject, summarized in his 'A Critique of the Theories of Pulmonary Evolution in the Mammalia,' such lithographs would form a valuable contribution to science." (Letter, April 27, 1936.)

Dr. Samuel W. Lambert:

"During thirty-five years he worked in embryology, in comparative anatomy, and in human anatomy . . . As an investigator he left the beaten track of his predecessors and his contemporaries and added to comparative anatomy an exact knowledge of the internal organs of the vertebrates, a subject which had previously been neglected by every anatomist. He was always a full-time man in that he worked in term time and in vacation, in his college laboratory and in a hut in the Canadian woods; he labored seven days a week and was at his dissecting table from eight in the morning until seven in the evening, and his evenings were given to reading . . . He wrote scientific monographs on his special pieces of investigation which left nothing further to be added by others. He left unfinished a study of the comparative anatomy of the lungs which is as thorough as his best previous work and which was still growing when his final premature breakdown came at the age of sixty-two. At the same time he had begun a study into historical medicine in which he emphasized the content and human interest of the text of some of the books of the 16th century, which are usually regarded purely as collections of anatomical drawings of academic interest alone."[7]

An even more adequate account of Dr. Huntington's scientific

[7] Bull. N. Y. Acad. Med., 1928, pp. 250-265.



work is given by Professor C. F. W. McClure in his Huntington commemorative articles.[8] He says:

"George Sumner Huntington played an important rôle in America in raising anatomy to the status of an independent science. He had a masterful knowledge of comparative anatomy, as is evidenced by the great anatomical collection which he personally prepared and organized. . . . He made a number of investigations, fundamental and exhaustive in character, of lasting importance. As during his lifetime, certainly in the future he will be recognized, both in America and abroad, as one of the great anatomists of his time."

In answer to my inquiry as to the chief ultimate objects of Huntington's scientific work, Professor McClure answered as follows:

"I might say that the chief aim of Huntington's investigations was to interpret man's structure from the standpoint of comparative anatomy and embryology. His principal interest concerned the morphology of the vascular system. Huntington and I collaborated with each other for about twenty years and although it may appear to be immodest for me to say so, the high point reached by our joint investigations was the establishment of the principle of the local origin of lymphatic endothelium from mesenchyme, as opposed to the view held by Florence Sabin that it sprouts off from the veins.

"Our view is concisely stated in the latest edition of Gray's Anatomy (p. 683) as follows: 'The earliest lymphatic endothelium probably arises, like the blood-vascular endothelium, by local transformations of mesoderm into endothelial islands which fuse into definite channels and plexuses. As with the blood-vascular endothelium this transformation ceases at different times in different regions and further growth and extension of the lymphatic endothelium takes place by sprouts from the already differentiated endothelium.'" (Letter October 17, 1936.)

The extent of Huntington's publications is given at the end of this memoir. It shows better than words could his interests and the results of his researches.

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[8] Science, March 23, 1928, LXVII, No. 1734, pp. 301-307. Bull. N. Y. Acad. Med., 1928, pp. 250-265. Am. Jour. Anat., Vol. XXXIX, No. 3, July 15, 1927, pp. 355-377.

MUSEUM

In connection with his scientific work George S. Huntington also established and built up a rich museum of human and comparative anatomy. This was begun with such odds and ends as he had inherited from his predecessors, in the cellars of the old College. When the new College was to be built on West 59th Street, Huntington helped materially to raise the funds for a separate four-story wing for anatomy, which henceforth was exclusively his and in which two floors were used as a museum, one as a laboratory and library, with the top floor constituting a part of the dissecting room. The basement contained the "menagerie," the formalin-preserved parts of bodies used for lectures, and the bone collection.

The bone collection, with which the writer became intimately identified, was begun in 1893. It started with a heterogeneous lot of unidentified older bones and skulls, to which was added a rather large series of Indian crania. From 1893 the bones of all the bodies dissected in the College, except those used for surgical demonstrations, were collected, provided with leaden tags bearing the number of the specimen with the year of dissection, boiled out in steam-piped vats, and during vacation time spread over the dissecting tables, under sky-lights, where they were left to partly dry and lose excess oil until fall, when they were placed in boxes and cases and taken down cellar. Professor Huntington personally was more interested in research on the soft parts, but he was fully aware of the prospective scientific value of the osteological material and so continued its collection.

When I began to visit the College in 1897 there was already an important accumulation of bones, for there passed through the dissecting room yearly over 150 bodies; but the bones were still in the original boxes. With the generous help of "the Professor," as he was most commonly referred to among us, the collection was properly segregated, arranged, stored in specially constructed racks, and partly numbered and catalogued. A system of a proper taking of the body length and some other useful measurements of the bodies to be dissected was put in operation,

and studies of the yearly augmented material were instituted. The collection was of unparalleled importance. Many of the subjects at that time came from the immigrants of various nationalities in which New York abounded and were neither abnormal nor decrepit; and each body carried with it identification as to nationality, sex, age, and cause of death. No such anthropologically valuable material existed at that time—nor in some respects exists today—in any other institution.

When I left New York for Washington the bone collection represented approximately 1700 individuals. It was not complete in all respects due to requirements of the dissecting room instruction and incidental conditions, but what was there was very precious for the student. Under the old financial conditions, the collection, as also everything in the museum, was the property of Huntington himself. So when the collection reached the limits of accommodation in its quarters and could neither be catalogued nor kept in order; when, furthermore, Huntington had need of rare embryological and other comparative material which could be furnished to him from the National Museum, while my division in the Museum had great need of basic osteological collections of the whites; and under the surety that a similar gathering could readily be made in the College, there were entered into a series of exchanges by which in the course of some years the entire older accumulation was transferred to Washington.

Meanwhile, partly with the writer's help, a large series of rare bone preparates was made for the growing anatomical museum; but this from the beginning was accompanied and surpassed by soft preparations in comparative anatomy, injections, and eventually reconstructions. In the words of Dr. Lambert, Huntington's:

"most active work as a collector was put forth in gathering together the dead bodies of the lower animals both of rare and ordinary species, from which he built his museum. These dead bodies came from the zoological parks, from the ships in the harbor which were importing animals for the menageries of the Hagenbecks and Barnums, also in special preservative cases from the most distant places of the earth. They arrived

in greater numbers than could be handled quickly, and the refrigerators at the College were full to overflowing with vertebrates on cold storage."[9]

Professor McClure adds important details to this, largely from Huntington's pen:

"As his collection gradually grew in size and importance, Doctor Huntington saw that in its further development he must adopt some definite plan leading to the establishment of a permanent museum of comparative anatomy which should illustrate to the fullest extent possible the morphological truths embodied in the doctrine of evolution. Such a plan was formulated by him and was published in 'Science' in 1901, under the title: 'The Morphological Museum as an Educational Factor in the University System.' In the scheme adopted by Doctor Huntington, there were to be two main divisions of the museum. The first was to be a general exposition of the cardinal points in anatomical structure as illustrated by the skeletal and locomotory apparatus, the circulatory and nervous systems, and the alimentary, respiratory, and urogenital tracts of each class, subclass, and order of vertebrates. 'This display,' he states, 'forms the guiding thread to the study of individual forms in respect to typical structures; i.e., the fundamental anatomical characters of the mammal, bird, reptile, amphibian, and fish are grouped together to afford a comprehensive view of the entire organism, from which starting point the detailed investigation of characteristic structures in their various modifications is to be followed through the series of species belonging to the *same class.*' The second main division of the museum deals with the development, comparative structure, and evolution of single organs and systems, illustrating the homologies and modifications of typical structures in each class of vertebrates. I may cite as an illustration of the plan followed in this division of the museum the wonderful series of preparations which he made dealing with the morphology of the ileocolic junction, cecum, vermiform appendix, and allied segments of the large intestine. In 1901, this particular series was illustrated by over six hundred preparations, including type forms of the ileocolic junction found in fishes, amphibians, reptiles, birds, and mammals, leading up to a detailed exposition and interpretation of the human cecum and appendix in all their variations, as had

[9] Lambert (Samuel W.) Bull. N. Y. Acad. Med., 1928, pp. 250-265.

been thus far observed by him and other anatomists. The work involved in this particular series was in itself an investigation of considerable magnitude, and some of the results of it have been embodied in a book published in 1903 and entitled 'Anatomy of the Human Peritoneum and Abdominal Cavity.'

"Naturally, the Morphological Museum was built up by Doctor Huntington largely as illustrative of his own investigations; it was his hope, however, that in its completed state it should constitute a kind of general morphological reference library, for he says: 'In this sense the museum fulfills its highest functions, stimulating and directly promoting investigation and rendering such investigation fruitful and effective by contributing the series necessary for comparison and reference.' In speaking of the relation of such a museum to other departments of the university, Doctor Huntington claims that morphology offers a series of modifications which different forms present in their structure—a field of almost unlimited choice from which the physiologist may select forms most suited for special experimental study. 'The Museum of Comparative Morphology converts a haphazard search for a suitable form into one which will select the most desirable type with certainty.' "[10]

The Huntington Museum, since his death, has had the fate of an orphan. It is still in the old building on 59th Street, and to the date of this writing no definite plans have been made as to its transfer or re-establishment. It appears to be partly a matter of finances, partly of finding those who could and would take proper care and use of it. Moreover, it has not been safe from some depredation and damage, all of which is a great pity. A list of its contents prepared by Mr. Petersen shows the following: temporal bone or ear series, 132; ileocecum series, 539; lung series, 647; genito-urinary system series, 796; general viscera series, 250; shoulder-girdle series, 29; salivary gland series, 262; heart series, 235; plaster cast series of muscular variations, 123; postcava and variations series, 86; chondocranium series, 12; brain series, 481; lymphatic series, 53; fetal series, 188; osteological series, 1312; microscopic slide series, 1046; photo-negative series, 8134; lantern slide series, 6602.

[10] McClure (C. F. W.) Am. Jour. Anat., Vol. XXXIX, No. 3, pp. 355-377.

LIBRARY

In connection with his laboratory and museum, Huntington built up gradually, at his personal expense, a large and valuable library in anatomy and comparative anatomy. This library was particularly rich in the older works. Among its 4,424 volumes it included 780 volumes published between 1483 and 1800, and 550 volumes from between 1800 and 1850. Among the older works, as catalogued by Mr. Petersen, were those of Berengarius, Bellini, Bartholemeus, Baptistae, Celsus, Casserri, Cowper, Aldrovandi, M. Albertus, Achillini, Ketham, Eustachius, Galini, Gersener, Grassdorff, Harvey (15 volumes), Laurentius, Valverde, Vessaeus, Vesalius (30 volumes). There were also close to 13,500 reprints.

The library, it is gratifying to state, was eventually acquired by the College.

In connection with this line of his activities, Huntington in 1922 started an elaborate work on the History of Medicine and in 1923 he had the first section of this publication ready for the printer.

MISCELLANEOUS ACTIVITIES

Professor Huntington did not engage in many activities outside of his classes and his laboratory. He was consulted by surgeons; in his laboratory and museum he was visited in the course of time by numerous prominent men in anatomy and comparative anatomy; he was one of the founders and editors of the *American Journal of Anatomy;* he served for four years as the president of the American Association of Anatomists and attended its meetings regularly; he was also for a time president of the New York Zoological Society, and a member of the advisory board of the Wistar Institute. But his heart was with his work alone and he cared but little for anything outside of the same. In harmony with this he was also a *bad* correspondent, answering but a very few letters. Dr. McClure tells me that even when they were actually collaborating he repeatedly had to send a man to New York, from Princeton, to get a reply to his letters.

In 1911, incidentally, he played an important part in a medico-legal case. He was the deciding witness in the trial of Albert Wolter, the degenerate slayer of Ruth Wheeler. It was his finding, in what remained of the charred left hand of the girl, of a few hairs which matched those of the slayer, that clinched the conviction of the latter and led to his execution.[11]

PHYSICAL TRAITS

There are, regrettably, no exact measurements and observations of George S. Huntington. He was somewhat above medium in stature, without being tall. His body and face were what could be described as well nourished or moderately stout, without any obesity. His hair, before greying, was brownish, his moustache and vandyke beard were slightly darker. In later years both the hair and the beard showed advancing greyness and the hair showed appreciable thinning, without baldness; by 1921 his hair was all white and beard grey. The eyes were blue or nearly so. The vault of his head was spacious but not high, the forehead medium, eyes moderately deep set, nose straight, lips, chin and lower face medium, ears of good size and regular, limbs muscular. He wore glasses in his work, but not otherwise. His teeth were regular and good. He was quick rather than slow in his movements, but always composed. His body, movement, behavior, showed absolutely nothing abnormal.

The frontispiece, from Dr. McClure's obituary article in the *American Journal of Anatomy* (kindly furnished by the Wistar Institute); the photograph showing Huntington in his early years, kindly furnished by his daughter, Mrs. O'Donnell; and especially the additional two photos which I owe to Dr. William Darrach, give him faithfully as he was.

QUALITIES AND CHARACTER

In his youth Huntington was thus remembered by one of his classmates at Trinity College:[12]

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[11] See record of the case in *Liberty*, April 4, 1936, p. 29.

[12] McClure (C. F. W.), George Sumner Huntington, An Appreciation. Am. Jour. Anat., XXXIX, No. 3, July 15, 1927, pp. 355-377.

"I can recall his personal appearance; he was of athletic build, blond, wearing a full beard; he had a pleasant voice and a very winning smile. He spoke with a German accent, causing the rest of us some occasional merriment by his mispronunciation of our English words."

As an undergraduate, Huntington is described as active in athletic sports and prominent in social life.

In the period of his medical studies he is thus commented on by Dr. Lambert:[13]

"Huntington had been educated in part in Europe and had a fluent command of French and German and a greater facility with Latin and Greek than most college graduates of his day. He had a body that knew no fatigue and a mind that took in every branch of medicine. During his second year he was the personal assistant of Dr. Sands, did the microscopic work of private patients, assisted at operations or gave ether for that leading surgeon of New York. He was prosector for Dr. Sabine, the professor of anatomy, and was taking private courses in pathology, in physical diagnosis, in the quiz class of Dr. Richard J. Hall, and read medical science enough hours to occupy him from sixteen to eighteen hours a day."

Still quoting Dr. Lambert:

"George Huntington was a born collector who studied his collections for their own value; he was not a mere acquisitor. Early in life he collected beetles and butterflies, and was no mean authority on the coleoptera. When a student in Germany and while at Trinity in Hartford, he collected early editions of the classical authors, especially the smaller editions in Greek and Latin of Elzevir and Aldus. As a young surgeon he collected the files of the journals containing the record of the development of the science of surgery which followed the epoch-making work of Lister. When he gave up surgery he presented his surgical collection to the library of the Lying-in Hospital, in which I was then most interested. His collection of books on anatomy is grouped about Vesalius as the central figure and is particularly strong in the publications of the 16th and 17th centuries. It forms almost a complete history of the renaissance of anatomy following the revolt from the Galenical traditions of fourteen centuries.

"His professional life was that of an intellectual enthusiast,

[13] Lambert (Samuel W.), Life and Work of George S. Huntington. Bull. N. Y. Acad. Med., 1928, pp. 250-265.

devoted to an ideal to make of it all that he could in the pursuit of his controlling goddess, the science of anatomy, and with him life was always short and art long.

"George Huntington left open for all students the gate to success in anatomical study, but he took no interest in the laggard or the dull-witted, and he chose his favorites on his own estimate of each man's ability alone.

". . . In comparative anatomy he built up a collection of specimens which is so varied, so complete, so full of unusual examples, that no other institution possesses anything like it."

Added to these capacities, in the words of Tilney,[14]

"was a prodigious memory made invaluable by a most voluminous scientific reading. This was of inestimable service to himself as well as to the members of his staff, for he could with the greatest of ease give references to former work along a great number of research lines."

As expressed by Van Beuren:[15]

"He had the very sincere affection of practically everyone who worked with him, but the students in general stood in great awe of him."

"To his colleagues and contemporaries he was most congenial and they all enjoyed his friendship."[16]

In the estimate of McClure, who knew him well for many years:

"He was a modest man who never sought praise. . . . All who came in contact with him in his prime were deeply impressed by his forceful character, his great physical and mental energy, his indomitable perseverance, his brilliant intellect, his great power of concentration, his unbounded enthusiasm and ambition. He understood all types of men and threw himself into their interests with sincere enthusiasm. He had great capacity for deep friendship. His rare combination of social and intellectual qualities accounts for the great influence he exerted, and made him so inspiring a teacher and leader that his name will long remain a tradition in the College of Physicians and Surgeons. In my own recollection George Huntington will always stand primarily as a friend and collaborator. From my first meeting with him I was attracted by his magnetic personality. His

[14] Tilney (Frederick), An Appreciation of Dr. George S. Huntington. Bull. N. Y. Acad. Med., second series, 1928, IV, pp. 254-260.

[15] Letter from F. T. van Beuren, Jr., June 2, 1936.

[16] Letter from Dr. Ellsworth Eliot, October 1936.

intense interest in whatever he touched, his creative imagination, and active, well-stored mind, never failed to vitalize his subject and to stimulate his co-workers to put forth their best effort."

As I knew him, he was always a man to be looked up to, from whom to expect his calm but sincere and naturally charming smile, to be sure of in everything worth while. He did not invite familiarity, yet could be simple and full of good humor on suitable occasions. There was no guile to him. He could get angry if anything went wrong with his lecture arrangements, but was never nervous nor irritable. He was very generous to everyone about him. In his laboratory his conduct was marked throughout by simplicity, taciturnity, concentration. He was a cordial friend to those whom he esteemed, without demonstrativeness. He gave no directions nor even intimations to those who worked with him, once he was satisfied about them. In meetings he spoke with erudition, demonstrated a good deal, but never argued nor attacked anyone. In congenial company he was quite human, but never initiative. He was logical and attached to facts with such deductions as they justified—never indulging in fancies or preconceived theories. His published work throughout is marked by entire reliability and completeness; but he followed promising lines of research with great eagerness. He was a man and teacher whose friendship was very precious.

About his family and private life we know less than would be desirable; I was able, however, to obtain some very interesting notes from Mrs. O'Donnell,[17] his eldest daughter. They are here given:

"As children, we were not close to my honored father. A large part of his time at home was spent in his study. He knew us girls and we knew him scarcely at all. In this connection, there is an amusing anecdote. It seems that when I was a few months old my nurse took me to the park for a ride in my baby carriage. On the way we met my father. He stopped us to look at me more closely, and said to the nursemaid, 'That's a fine, healthy-looking child you have there, whose is it?' 'It's yours, Doctor,' the nurse answered . . .

[17] Letter, October 17-18, 1936.

"My mother seemed to fear my father, and that same fear, or semblance of fear, communicated itself to all their servants and to the governesses who had charge of us girls. But I have always thought it a remarkable tribute to the trust and respect that my father inspired in us . . .

"As to my father's likes, dislikes, disposition, hobbies, I will tell you what I can. He did not care for music, tho he had two favorite tunes—'Annie Laurie' and 'Fair Harvard'—which he used to pick out on the piano with one finger! He used to say that his musical 'bump' must be a 'dent.'

"He was a most versatile man, physically as well as mentally. He spoke French and German, was a lover of the classics, was always deeply interested in history—especially the story of feudal times, and was quite an authority on the traditions, coats of arms, etc., of ancient British families. He was active in athletics and many kinds of outdoor games and sports. He swam, played tennis, pitched quoits and was fond of archery. He drove his own horses, but was always 'leery' of automobiles. He could sail or row a boat and could paddle a canoe like an Indian. He enjoyed camping trips in the Canadian woods, during which he and his few friends would carry weighty packs. My father was well-versed in woodcraft of every kind. He liked fishing, but always seemed especially devoted to big game hunting. He was very fond of animals, especially of dogs, of which he kept about him, at all times, a good number and of various breeds. Some of these canines attained a venerable age; he had one little female water spaniel that followed him everywhere and reached the age of 21 years.

"Father was a skilled carpenter and used to make delightful rustic furniture fashioned from the white and silver birches on our Canadian estate. He possessed a large collection of rare moths and butterflies to which he was constantly adding.

"But I think that of all his hobbies—all his varied diversions—gardening was first, last and always his pet pastime. He took a great pride in his garden, a good-sized one—about 50 x 300 feet, and 'worked' it almost unaided. He also took an interest in 'crossing' fruits and vegetables. He had too a fine flock of sheep and an imported Lincolnshire ram of which he was very proud.

"His disposition, for the most part, was mild, although he could be severe when the occasion warranted. He had a charming and gracious manner and a quite delicious sense of humor. He was very popular with both men and women and had hosts of loyal friends.

"One of the most beautiful traits in my father, I always felt, was his modesty. He never sought praise. While not a religious

man in the ordinary sense, he was a strictly moral one and had a great respect for women. He was possessed of seemingly unbounded physical and mental energy, remarkable perseverance and unusual powers of concentration, all joined to a youthful enthusiasm."

INCIDENTS

Those who were associated with George S. Huntington recall many a mirthful incident in which wittingly or unwittingly he played a part. He was not in the least a joker, though possessing a good healthy sense of humor, but conditions sometimes played a joke upon him. Some of these are narrated by Lambert:[18]

"No one who was working at the Sloane or Vanderbilt Clinic in 1894 can ever forget the arrival at the College of the camel. This dead beast was delivered at the College yard at 3 p. m. on Friday, July 2. New York was enjoying one of its hot spells. The Hicks family, both Gilbert and Eddie, were gone for the week-end. Not even the Professor was on hand, and the unwelcome camel lay in the sun by day and the heat by night, with the temperature ranging from 80 odd to 96 in the shade, during the holidays of July 3, 4, and 5, Saturday to Monday. The travelers on the elevated road a block away thought that a terrible epidemic had befallen Roosevelt Hospital, and the whole neighborhood mourned over the death of that particular camel. On Tuesday the Board of Health came to the rescue and the deceased was promptly buried at sea.

"On one winter's day Eddie Hicks, the dissecting room attendant, received in a gunny sack a 'dead' South American python, from a ship near the Battery. On the way up town the bag, which was big with a 16-foot snake, was laid next to the steam pipes on the elevated. As Eddie went down 59th Street to the College, the rotten sack gave evidence of active peristalsis, but fortunately did not burst open until the laboratory was reached, when the boa constrictor was overcome, but not without a long struggle. He died shortly, a violent death, and his insides adorn the museum.

"When Jumbo, the pride of London and the triumph of Barnum, died, his skeleton and his hide went to the Museum of Natural History, but his entrails went to the College and his ileocecal junction forms a prominent dried specimen in the Huntington collections.

[18] Lambert (Samuel W.) Bull. N. Y. Acad. Med., 1928, pp. 250-265.

"Many other vicissitudes of fortune befell during the collecting of Dr. Huntington's specimens. His dissections are models of neatness and dexterity and show minute details. His laboratory was a dusty, uncared-for chaos in which the individual specimens formed cases illustrating the scientific accuracy of a genius. His catalogue was in his own head, and he knew what he had and where he had left it, and woe to him who had moved its position."

On an occasion recalled by Dr. Eliot (letter, October 1936), the

"sacred museum and laboratory, which was always kept under lock and key, was in some way invaded by a student prosector, who was detected and roundly scolded by the Professor. . . . The collections and preparations still occupy the old quarters in ghost-like seclusion, no provision having been made for them in the anatomical department of the present medical center."

To quote further from Eliot:

"Day after day, Huntington was always to be found in the laboratory, and he lived and breathed anatomy and cigarettes, being rarely without one of those 'weeds' as he worked. This extensive sedentary occupation may have been responsible for his early breakdown, for he was naturally strong and robust . . .

"His knowledge of comparative anatomy was so extensive that once it enabled him to distinguish the bones of a rodent which was served for terrapin at a luncheon he gave to some colleagues. The steward charged with the deception was compelled to admit it and to strike the item from the luncheon check."

In the bone room in which I worked and where there was a large sink, the Professor kept for many years a beast of a big old box turtle, which crawled over the bones, knocked things down and was in its waking hours a general nuisance. Why of all the "menagerie" this turtle alone escaped dissection, I never knew, but there he was, without visible means of sustenance, for I never saw any indications that it had been fed. It was in the room as long as I kept coming—even after I went to Washington.

Once during a visit Dr. Huntington invited me to lunch with him. He brought a good-sized, astonishingly neat package; we went to the very top of the building, climbed through a window in the roof, went over the roof to a door in a sort of a chemicals-

filled coop built on the roof over the main building for the photographer, found a stool and a box, and then he opened the package which was filled with excellent sandwiches and cake neatly wrapped. The Professor then heated coffee in a big beaker over a Bunsen burner, poured it, without bothering about possible former contents, into a graduated jar, got a couple of smaller beakers for cups, and thus we feasted. This was the usual way Huntington lunched when not obliged to leave his laboratory.

And there were of course the cigarettes. There were many each day, except when he was preparing for a lecture. But there was not the slightest sign of the cigarette-addict—just a deliberate and normal, if a bit profuse, consumption.

Huntington's outfit in the laboratory consisted invariably of blue overalls with a front piece and a couple of suspender bands; otherwise in shirt sleeves. The laboratory was always quiet, except for the doings of the mechanic at his bench on the side of the hall that faced toward 60th Street.

Facing 59th Street was the long table where Petersen was making his drawings, and along the side next to the main College building was a long bench for one or two collaborators—I never saw at one time a larger number. Most of the remaining space in the large room was filled with all sorts of receptacles for specimens and whole animals in their preserving fluids, awaiting study. The inside was kept thoroughly in order as far as was possible, even if the windows were neglected, and nothing could be displaced without incurring the wrath of Huntington, who knew of every item on the floor. The whole was a research sanctuary in which Huntington and others spent many highly interesting and happy hours.

ILLNESS

In 1914, apparently without any premonition, Huntington had a light stroke. From this he rallied and was for a period again in fair health. According to his daughter, Mrs. O'Donnell (letter October 21, 1936):

"Some time before I left New York, my father had suffered a stroke—it may possibly have been two strokes, on this point

I am not clear. I saw him shortly after his first stroke. At that time his speech was affected, but later he recovered the power of speaking clearly, I remember. Paralysis left him with one bad leg; he was obliged to give this leg a sort of swinging motion from the hip and to drag it when he walked. I do not recall that his mind was affected in the slightest degree by the paralytic strokes. He read, studied, and conversed as usual, even when confined for a considerable time to his chair. His second wife nursed him with little assistance."

A letter from Dr. Samuel W. Lambert (January 13, 1937) gives the following details:

"I took care of Dr. Huntington in his various attacks of paralysis and in his last illness. I was assisted by Dr. Irving Pardee, whom I have consulted about details, and earlier by Dr. Frederick Tilney.

"As usual when doctors treat one of their profession, no notes or history were ever written or kept. My recollection is that he had at first a cerebral attack with paralysis of the left arm. This was quite temporary and although the symptoms lasted an appreciable time, he did as good work as ever for twelve years, when he began to have recurrences. One of his 'strokes' had no symptoms of muscular paralysis but a complete uni-lateral anesthesia which was so marked that when he turned on his left side in his sleep he immediately awoke with a sensation of floating in the air or falling. I have never heard any other patient describe this symptom in this way before or since. During the last three years of his life he had a series of small cerebral attacks, which I took to be thrombotic, and he finally died in such an attack, being unconscious for the better part of a week. During the five years before he died he showed distinct lack of mental power compared with his old energetic self.

"One of his last activities was taking up translation from the Latin of the work of Berengarius. This manuscript is in existence and consists only of translations and notes. There is no continuous text.

"During the last two years of his life, the department at Columbia was run by his brother-in-law, Bern B. Gallaudet, without change in educational methods.

"Huntington died on January 5, 1927, and I signed the death certificate: 'General arterio-sclerosis; thrombosis of cerebral arteries'."

There was no autopsy. The body was cremated and buried, at his own desire, in Hartford, in the Huntington plot.

In 1924 Professor Huntington resigned from the College. This resignation was accepted with deep regret by all concerned, and the following resolution, for a copy of which I am indebted to Dr. van Beuren, was passed:

"RESOLVED, That the Faculty of the College of Physicians and Surgeons, Columbia University, upon the occasion of the retirement from active duty of their colleague, Dr. George S. Huntington, place on record their deep appreciation of his signal services to the institution and express their heartfelt regret that his active association with the teaching work of the college is to cease. During the long period of his professional work, extending uninterruptedly over thirty-five years, Professor Huntington developed the teaching of anatomy at this College from the very rudiments up to its present high degree of efficiency; from a series of casual lectures and unrelated dissections into a carefully integrated and scholarly course in histological and gross morphology with special reference to ontogenetic and phylogenetic relationships for the better comprehension of variations in the adult human forms. The morphological museum is the outgrowth of his personal enthusiasm and farsighted vision. The great mass of teaching material it contains is largely the work of his own hands, a lasting memorial of his great material service to the School of Medicine. But beyond and above this have been his spiritual services; the high enthusiasm with which he has imbued his students; the splendid loyalty he has bred in his assistants; the generous emulation he has inspired among his colleagues. He brought to his teaching both the highest degree of scientific knowledge and the humanity of a wide and liberal culture in literature and in the art of living. The confines of the laboratory and the constant devotion to scientific attainment have never narrowed his sympathies nor limited his view. His personality has mellowed and broadened through the years of strenuous endeavor often made more rigorous by physical ills. His kindly solicitude and generous interest has made him dear alike to students and instructors. More than all else we see in him embodied that spirit of service to science and to humanity which is at once the goal and the reward of all our labors. Our regret for the loss of his active participation in our academic problems is tempered by our understanding of his relief in laying aside those burdens of teaching and administration that have pressed so heavily upon him for so long. But we confidently look forward to the continuance of his interest in our plans, of his sympathy for our endeavors and of his ready response to our calls for his wise counsel."

BIBLIOGRAPHY

The following bibliography, which has been gathered partly by Professor McClure, partly by Mr. Petersen, shows the extent of Huntington's scientific interest, and also the works of others that originated in his laboratory and in most of which he was more or less instrumental.

1892

The ileo-colon of Procyon lotor and allied forms. Trans. N. Y. Acad. Sci., XIII.

1893

The kidney of Elephas indicus. Trans. N. Y. Acad. Sci., XIII.

Studies in the development of the alimentary canal. Med. Rep. Soc. Lying-in Hospital of N. Y. City.

1894

The museum of human and comparative anatomy. Columbia Univ. Bull.

1895

The significance of muscular variants, as illustrated by reversions in the anti-brachial flexor group. Trans. N. Y. Acad. Sci., XIV.

1897

Contribution to the topographical anatomy of the thorax in the fetus at term and the new-born child. Med. Rep. Soc. Lying-in Hospital of N. Y. City.

On some points in the formation and distribution of the cervical plexus in Cynomorphous monkeys. Trans. N. Y. Acad. Sci., XVI.

Corrosion anatomy, technique and mass. Proc. Assoc. Am. Anat., IX Session, Washington.

1898

The eparterial bronchial system of the mammalia. Ann. N. Y. Acad. Sci., XI.

Contributions to the myology of Lemur bruneus. Trans. N. Y. Acad. Sci., XVI.

The teaching of anatomy. Columbia Univ. Bull. for June.

(With Gerrish and Wilder). Report of the majority of the Committee on Anatomical Nomenclature. Proc. XIth Annual Session Assn. Am. Anat., New York; also in Jour. Anat. and Physiol., XXXII.

Comparative anatomy and embryology of vertebrates as aids in the teaching of human anatomy in the medical course. Am. Jour. Med. Sci. for December.

1901

The morphological significance of the periclavicular supernumerary muscles. Ann. N. Y. Acad. Sci., XIV.

The morphological museum as an educational factor in the university system. President's address before Assn. Am. Anat., XIVth Session, Baltimore, 1900. Sci., XIII.

1903

Present problems of myological research and the significance and classification of muscular variations. Am. Jour. Anat., II.

Anatomy of the human peritoneum and abdominal cavity. Phila.

1904

The derivation and significance of certain supernumerary muscles of the pectoral region. Jour. Anat. and Physiol., XXXIX.

1907

Methods and scope of natural object teaching in the medical school. Columbia Univ. Suppl. for December.

The genetic interpretation and surgical significance of some variations of the genito-urinary tract. Harvey Lectures, series II.

Valedictory address to the graduating class of the Jefferson Medical College, Philadelphia. Sci., XXVI.

(With McClure, C.F.W.) The development of the main lymph channels of the cat in their relation to the venous system. Proc. Assn. Am. Anat., XXI Sess., New York; Anat. Rec., I (Am. Jour. Anat., VI).

(With McClure, C.F.W.) The interpretation of variations of the postcava and tributaries of the adult cat, based on their development. Proc. Assn. Am. Anat., XXI Sess., New York; Anat. Rec., I (Am. Jour. Anat., VI).

(With McClure, C.F.W.) Development of postcava and tributaries in the domestic cat. Proc. Assn. Am. Anat., XXI Sess., New York; Anat. Rec., I (Am. Jour. Anat., VI).

1908

(With McClure, C.F.W.) The anatomy and development of the jugular lymph sacs in the domestic cat. Anat. Rec., II.

1910

(With McClure, C.F.W.) The anatomy and development of the mammalian jugular lymph sacs. Am. Jour. Anat., X.

The phylogenetic relations of the lymphatic and blood-vascular systems in vertebrates. Anat. Rec., IV.

The genetic principles of the development of the systematic lymphatic vessels in the mammalian embryo. Anat. Rec., IV.

Ueber die Histogenese des lymphatischen Systems beim Säugerembryo. Anat. Anz., Ergänz z. Bd. XXXVII, Verh. 2, Internat. Anat. Kongr., Brüssel.

1911

The anatomy and development of the systemic lymphatic vessels in the domestic cat. Parts I and II. Memoirs of the Wistar Inst. of Anat. and Biol., no. 1, Philadelphia.

The development of the lymphatic system in reptiles. Anat. Rec., V.

Die Entwickelung des lymphatischen Systems der Vertebraten vom Standpunkte der Phylogenese des Gefässystems. Anat. Anz., XXXIX.

1913

The development of the salivary glands in the lower primates. Contrib. fr. George Crocker Research Lab., IV, Columbia University Press.

The genetic interpretation of the primate alveolingual salivary area. Contrib. fr. George Crocker Research Lab., IV, Columbia University Press.

1914

The development of the mammalian jugular lymph sac, of the tributary primitive ulnar lymphatic and of the thoracic ducts from the viewpoint of recent investigations of vertebrate lymphatic ontogeny, together with a consideration of the genetic relations of lymphatic and hemal vascular channels in the embryos of amniotes. Am. Jour. Anat., XVI.

The genetic relations of lymphatic and hemal vascular channels in the embryos of amniotes. Proc. Am. Assn. Anat.; Anat. Rec., VIII.

1915

The development of the lymphatic drainage of the anterior limb in the cat. Proc. Am. Assn. Anat.; Anat. Rec., IX.

1916

The significance of different and distinctive types of bronchial architecture within the same order of mammals. Proc. Am. Assn. Anat.; Anat. Rec., X.

1917

The morphological basis for the dominant pulmonary asymmetry in the mammalia. Anat. Rec., XI.

1918

Mutation in mammalian evolution. Proc. Am. Assn. Anat.; Anat. Rec., XIV.

Modern problems of evolution, variation and inheritance in the anatomical part of the medical curriculum. Anat. Rec., XIV.

1919

The morphology of the pulmonary artery in the mammalia. Anat. Rec., XVII.

1920

Homoögenesis in the pulmonary evolution of the mammalia. Proc. Am. Assn. Anat.; Anat. Rec., XVIII.

A critique of the theories of pulmonary evolution in the mammalia. Am. Jour. Anat., XXVII.

(With McClure, C.F.W.) A series of diagrams explanatory of the development of the postcava, with especial reference to the supracardinal system of veins. Proc. Am. Assn. Anat.; Anat. Rec., XVIII.

(With McClure, C.F.W.) The development of the veins in the domestic cat (Felis domestica) with especial reference—1) to the share taken by the supracardinal veins in the development of the postcava and azygos veins, and 2) to the interpretation of the variant conditions of the postcava and its tributaries, as found in the adult. Am. Jour. Anat., XXVIII.

(With McClure, C.F.W.) The mammalian vena cava posterior. An ontogenetic interpretation of the atypical forms of Vena cava posterior (inferior) found in the adult domestic cat and in man. The Am. Anat. Mem., 1929, No. 15. Published by Professor McClure after Huntington's decease.

LIST OF OTHER PUBLICATIONS FROM OR BASED ON THE COLLECTIONS OF HUNTINGTON DEPARTMENT OF ANATOMY, COLLEGE OF PHYSICIANS AND SURGEONS

1895

Fossa capitis femoris, with observations on a tubercle occupying the trochanteric fossa. F. J. Brockway.

1897

A contribution to the topographical anatomy of the mediastinum and the superior aperture of the thorax. Joseph A. Blake.

1898

Modern problems of evolution, variation and inheritance in the anatomical part of the medical curriculum. Amer. Jour. Med. Sci. for December. p. 3.

The roof and lateral recesses of the fourth ventricle, considered morphologically and embryologically. Joseph A. Blake.

Study of the normal tibia: Aleš Hrdlička.

Dimensions of the normal pituitary fossa or sella turcica in the white and Negro races. Aleš Hrdlička.

1899

The relation of the trachea and bronchi to the thoracic walls, as determined by the Roentgen rays. Joseph A. Blake.

Atresia of the aortic orifice due to anomalous development of the auricular septum. Joseph A. Blake.

Eskimo Brain. Aleš Hrdlička.

1900

The relative bearing of the conjoined tendon and the internal oblique muscle upon the radical cure of inguinal hernia. Joseph A. Blake.

A preliminary communication. The topography of the paraceles in their relation to the surface of the cerebrum and the cranium. Ed. A. Spitzka.

Arrangement and preservation of large collections of human bones for purposes of investigation. Aleš Hrdlička.

1901

Contribution to the osteology of ribs. Aleš Hrdlička.

Typical forms of shaft of long bones. Aleš Hrdlička.

Certain racial characteristics of the base of the skull. Aleš Hrdlička.

An Eskimo brain. Aleš Hrdlička.

1902

Contributions to the encephalic anatomy of the races. E. A. Spitzka.

1903

A study of the brain weights of men, notable in the professions, arts and sciences. Ed. A. Spitzka.

Divisions of the parietal bone in man and other mammals. Aleš Hrdlička.

The post-orbital limbus. A formation occasionally met with at the base of the human brain. Ed. A. Spitzka.

1904

The perineum and perineal body. Churchill Carmalt.

1907

Variations in the postcava and its tributaries as observed in 605 examples of the domestic cat. William Darrach.

The range of variations in monotremes and Australian marsupials. H. von W. Schulte.

A study of the brains of six eminent scientists and scholars belonging to the American Anthropometric Society together with a description of the skull of Professor E. D. Cope. Ed. A. Spitzka.

1908

Further communications on the venous system of marsupials. H. von W. Schulte.

1909

A note on the organization of the venous return with especial reference to the iliac veins. H. von W. Schulte and Frederick Tilney.

1910

A note on the post-cardinal omphalo-mesenteric communications in the adult mammal. Alfred J. Brown.

1912

The development of the axial veins and lymphatics in Tragulus Meminna Erxleben. Frederick Tilney.

1913

An analysis of the juxta-neural epithelial portion of the hypophysis cerebri, with an embryological and histological account of a hitherto undescribed part of the organ. Frederick Tilney.

Histogenesis and morphogenesis of the thoracic duct in the chick; development of blood cells and their passage to the blood stream via the thoracic duct. Adam M. Miller.

Hemophoric function of the thoracic duct in the chick. Adam M. Miller.

1914

Experiments on the development of blood vessels in the area pellucida and embryonic body of the chick. Adam M. Miller and John E. McWhorter.

The early stages of vasculogenesis in the cat (Felis domestica) with especial reference to the mesenchymal origin of endothelium. H. von W. Schulte.

1915

Reminiscences of recent years at the College of Physicians and Surgeons. H. von W. Schulte.

Development of the neuraxis in the domestic cat at the stage of twenty-one somites. H. von W. Schulte and Frederick Tilney.

The morphology of the diencephalic floor. A contribution to the study of craniate homology. Frederick Tilney.

A case of unilateral cerebellar agenesia. Oliver S. Strong.

The origin and early development of the posterior lymph heart in the chick. Randolph West.

1916

The development of the vertebral column in the domestic cat from the membranous to the completion of the cartilaginous stage. Alfred J. Brown.

The fusion of the bilateral anlagen of the heart and the formation of the bulbo-ventricular loop in embryos of the cat. H. von W. Schulte.

The fusion of the cardiac anlagen and the formation of the cardiac loop in the cat. H. von W. Schulte.

The anatomy of a fetus of Balaenoptera borealis. H. von W. Schulte.

The chondrocranium of a 20 mm. human embryo. John D. Kernan.

The development of the occipital region of the domestic cat with an interpretation of the paracondyloid process. John D. Kernan.

The supra-optic canal, its morphology and anatomical relation to choked disc. Frederick Tilney.

1917

The early stages of the development of the great veins and of the hepatic circulation in the cat. H. von W. Schulte.

The structure of the skull of ziphius. John D. Kernan.

The position of the respiratory vascular net in the allantois of the chick. Vera Danchakoff.

1918

Cell potentialities and differential factors, considered in relation to erythropoiesis. Vera Danchakoff.

Equivalence of different hematopoietic anlages (by method of stimulation of their stemcells). II. Grafts of adult spleen on the allantois and response of the allantoic tissues. Vera Danchakoff.

1919

The development of the cardiac loop in the rabbit with special reference to the bulbo-ventricular groove and origin of the interventricular septum. Henry A. Murray, Jr.

Digestive capacity of splenic adult mesenchyme as factor in tumor destruction. Vera Danchakoff.

1921

Digestive activity of mesenchyme. (A) The Ehrlich sarcoma cells as object. Vera Danchakoff.

1922

Digestive activity of mesenchyme and its derivatives. Vera Danchakoff and S. M. Seidlin.

1923

Wachstum transplantierter embryonaler gewebe in der allantois. Vera Danchakoff.

1924

Growth and development of the neural plate in the allantois. Vera Danchakoff and Anna Agassiz.

1926

A new type of examination for medical students. Mather Cleveland.

Situs Inversus Viscerum. Mather Cleveland.

Charles E. St. John

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CHARLES EDWARD ST. JOHN

1857–1935

BY

WALTER S. ADAMS

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CHARLES EDWARD ST. JOHN

1857–1935

BY WALTER S. ADAMS

Charles Edward St. John, member of the staff of the Mount Wilson Observatory of the Carnegie Institution of Washington for twenty-two years, died at Pasadena, California, on April 26, 1935. During the last five years of his life he was Research Associate of the Institution and continued active investigation until shortly before his death. He was elected to the National Academy of Sciences in 1924.

St. John was born at Allen, Michigan, on March 15, 1857. He came of an old English family, being descended directly from Matthias St. John who came from England to Massachusetts in 1632. Successive generations lived in New England and New York, but about 1850 St. John's father and mother moved westward to Michigan where the father, Hiram A. St. John, took up the trade of millwright in a new and undeveloped country. The mother, Lois Bacon, was born in central New York. Her mother had lived for many years in Williamstown, Massachusetts, and transmitted to her children many of the intellectual interests which she had developed in this college town. St. John's mother received an exceptionally good education for the period and retained throughout her life a wide interest in reading, public affairs and the changing life of the country. She was the intellectual companion of her children and her influence upon their development must have been great.

Charles St. John was the youngest of a family of four sons and two daughters. One brother of exceptional promise died of a brain lesion at the age of 34. A second after three years' service in the Civil War studied law and developed into one of the leading attorneys of southern Michigan. The two sisters were women of marked intellectual ability: one became a successful and influential teacher and the other a business woman of unusual capacity.

As a boy St. John was not physically strong and his education proved a severe tax upon his constitution. He entered Michigan Normal College in 1873 and was graduated at the age of nineteen, the youngest member of his class. During this period he greatly overtaxed his strength and for the next ten years he was incapacitated for further study. It is probable, however, that these were the years in which he built up the philosophy of life which he followed throughout his career. As his health recovered he undertook an instructorship in physics and chemistry at the Normal College and in 1887, at the age of thirty, received the degree of Bachelor of Science from the Michigan Agricultural College. The need for severe economy at this time obliged him to combine teaching with the continuance of his studies. After two years of graduate work, mainly in electricity and magnetism, at the University of Michigan, he went to Harvard University where he received the degree of Master of Arts in 1893. The award of the John Tyndall Fellowship enabled him to spend a year abroad at the University of Berlin after which he returned to Harvard and obtained the degree of Doctor of Philosophy in 1896 at the age of thirty-nine. The advanced age at which he reached this important stage in his education bears eloquent testimony to the tenacity of his purpose in the face of severe physical and financial handicaps.

The courses at Harvard which St. John followed during his graduate study dealt largely with problems of electrical conduction and self-induction, magnetic permeability and similar subjects which formed an important part of the theoretical and observational physics of that period. His first extensive publication was a paper on the *Wave-Lengths of Electricity on Iron Wires* which appeared in the American Journal of Science in 1894. In Berlin his work had to do mainly with the radiation of black bodies, and a valuable article giving some of his results was published by him in the Annalen der Physik und Chemie in September 1895. At Harvard he studied chiefly under Trowbridge and B. O. Peirce, and the fundamental training he received under these eminent teachers proved of the greatest value to him in his future work. It is clear that even at this time

problems connected with radiation held a strong attraction for St. John, an interest which developed with the years which brought him into contact with spectroscopy.

After leaving Harvard, St. John was for one year Instructor in Physics at the University of Michigan and then accepted an appointment as Associate Professor of Physics and Astronomy at Oberlin College. He remained at Oberlin for eleven years, becoming Professor of Physics in 1899 and Dean of the College of Arts and Sciences in 1907. He left Oberlin to become a member of the staff of the Mount Wilson Observatory in the summer of 1908 at the age of fifty-one.

As a teacher at Oberlin, St. John was remarkably successful and held the interest and affection of his students to an unusual degree. Dealing with relatively small classes, he was brought into intimate contact with the individual students by whom his remarkable enthusiasm and love of knowledge in every form were appreciated and respected. Many of these students later went out into careers of teaching or scientific research, and St. John's influence was often a determining factor in their after lives. Perhaps the most striking characteristic in his teaching, apart from his enthusiasm, was his love of accuracy and his intolerance of vagueness and lack of precision, whether in the statement or the solution of a problem. He had an extraordinary capacity for concentration which frequently made him oblivious to his surroundings, both within and without the classroom, and his absent-mindedness was proverbial throughout his life. His chief interest lay in advanced and graduate, rather than elementary, student courses and to these he brought the clearness of exposition and demonstration which characterizes the exceptional teacher.

It is rarely that one who has been engaged in teaching for many years and has taken part in administrative work is desirous at an age of more than fifty of changing his life completely and entering upon pure research. But the research instinct was very strong in St. John's mind, as was clearly indicated by the character of his work while a graduate student at Harvard and Berlin. When a teacher at Oberlin he spent several summers,

beginning in 1898, at the Yerkes Observatory where he worked with Dr. E. F. Nichols on the first successful attempts to measure stellar radiation with a radiometer. It was here too that he first met Dr. George E. Hale and others of the staff who later formed a part of the group at Mount Wilson. Accordingly, when Dr. Hale offered him in 1908 a position on the Mount Wilson staff he accepted gladly, partly because of the increasing strain of the administrative responsibilities at Oberlin, but chiefly because of the opportunity afforded him of realizing the desire for research which had been so close to his heart for many years. In July 1908 he arrived at Mount Wilson and began his new work.

At this time the Mount Wilson Observatory was still in an early stage of development. The 60-inch reflector was under construction, but the only telescopes available for use were the two solar instruments, the Snow horizontal telescope and the 60-foot vertical telescope. Both were equipped with powerful spectrographs and spectroheliographs. The spectroscopic laboratory in Pasadena had been completed and the small laboratory on Mount Wilson, where the spectra of arc and spark light-sources could be studied and compared with solar spectra, was still used for investigations not requiring heavy currents. It was natural, accordingly, that St. John should enter the field of solar spectroscopy, a field which at just this period was of exceptional interest. In the summer of 1908 Hale had discovered the vortical character of sun-spots, which was immediately followed by the fundamental discovery of the existence of magnetic fields in spots. Two years previously the photography of sun-spot spectra and comparison with the spectrum of the iron arc at different temperatures (an investigation carried on simultaneously by A. Fowler in England) had provided the first definite evidence for the separation of lines into temperature classes and had explained the principal features of the sun-spot spectrum. The immense importance of this work in its application to the analysis of spectra and to a rational understanding of solar and stellar phenomena was just being recognized. In addition, the important differences between the spec-

trum of the center and the limb of the sun had just been discovered, and the possibility under fine observing conditions of photographing the flash spectrum without an eclipse had been fully established. In short, the field of solar physics and spectroscopy was filled with problems of great variety and remarkable interest.

Once started upon his investigations, St. John pursued them with extraordinary enthusiasm and energy. In the period between 1909 and 1930 he published eighty papers, either individually or in collaboration with other members of the Mount Wilson staff. Most of these, especially those of greater length, appeared in the Astrophysical Journal as Contributions from the Mount Wilson Observatory. He also prepared several extensive committee reports which were published in the Transactions of the International Astronomical Union. Shorter communications appeared in the Proceedings of the National Academy of Sciences, the Publications of the Astronomical Society of the Pacific, the Physical Review and the publications of numerous scientific societies. The Revision of Rowland's Preliminary Table of Solar Spectrum Wave-Lengths was issued in book form by the Carnegie Institution of Washington.

In a broad way St. John's investigations may be analyzed into six groups all of which are more or less interrelated:

1. Motions and circulation in sun-spots.
2. General circulation and levels in the solar atmosphere.
3. Wave-lengths and displacements of solar and terrestrial lines with application to the theory of generalized relativity.
4. Spectroscopic measurements of the rotation period of the sun.
5. Identification of elements in the solar spectrum.
6. Application of solar results to planetary and stellar spectra.

Beginning with accurate measurements of the wave-lengths of the important H and K lines of ionized calcium, St. John made a detailed quantitative study of their behavior and displacements in sun-spots and adjacent regions on the sun's surface. From this investigation he found that in the great ma-

jority of cases calcium vapor is descending over the umbrae of spots with velocities of as much as two km a second. Radial motions inward across the penumbrae and occasional rotary motions were also observed. He concluded that in the case of sun-spots there appears to be a local system in which the emitting vapor rises around the flocculi, flows across the penumbra, and is then drawn downward into the umbra, with or without vortical motion.

The results of this investigation and the discovery by Evershed in the spring of 1909 of the displacement of solar absorption lines in the penumbrae of sun-spots led St. John to undertake a very extensive series of measurements involving some 500 lines of different elements. An analysis of his results, besides affording full confirmation of Evershed's hypothesis that the displacements are due to motion of the solar gases tangential to the sun's surface and radial to the axis of the spot vortex, showed larger displacements for the lines of longer wave-length and systematic differences depending upon the intensities of the lines and upon the elements involved. On the basis of this material St. John built up a diagrammatic representation of the probable mode of circulation of the different gases in a sun-spot vortex which is of great interest and permanent value.

At an early period in his solar investigations St. John discovered the pressing need for accurate measures of wave-length of spectrum lines, both in the sun and in laboratory sources. In 1912 accordingly, commencing with the spectrum of the iron arc, he began those extensive measurements which continued almost to the end of his life and form a collection of material of great value to investigators in spectroscopy. This work appealed to St. John especially on two grounds: first, because of the pleasure he took in quantitative studies of high precision; and second, because of the wide and important applications to problems relating to the solar atmosphere which this material afforded.

The investigation of the iron spectrum was carried out in a most careful and painstaking way. The effect of radiation from near the poles of the arc upon the character and the wave-lengths

of the spectrum lines was studied in detail and the type of arc best adapted for accurate measures of wave-length was fixed upon after much examination. The hundreds of lines selected for measurement were classified according to their physical behavior in the arc, and the measures themselves were made, not only on photographs taken with large grating spectrographs, but also through the collaboration of Babcock of the Mount Wilson staff on spectrograms obtained with the Fabry-Perot interferometer. The resulting wave-lengths are among the most accurate ever made in spectroscopy and form an essential part of the list of secondary iron standards of wave-length adopted by the International Astronomical Union.

In 1914 St. John made a study of the effective levels in the solar atmosphere at which absorption lines of different elements originate. For this purpose he compared the results obtained by Mitchell at solar eclipses with his own results derived from measurements of displacements over sun-spots and found an excellent degree of correlation. The gases of the elements with the strongest solar lines extend to the greatest height, and for any one element the effective level is highest for the strongest lines. The enhanced lines (those due to the ionized element) extend to higher levels than the normal (neutral) lines of the same element. The problem of levels in the sun's atmosphere always interested St. John greatly, and although the later development of the theory of ionization by Saha partially modified some of St. John's conclusions, he continued to hold to most of the views he developed at this time.

In this same year St. John commenced his extensive spectroscopic investigation of the rotation of the sun, a research which he carried on throughout the remaining years of his life. Using the 17-inch solar image at the 150-foot tower telescope, he developed an improved method of photographing the spectra of the opposite limbs of the sun and extended his observations to include, not only the region in the green portion of the spectrum which was first undertaken in cooperation with other observatories but also parts of the violet and of the red regions. In the red he utilized atmospheric lines to serve as a check upon the

accuracy and adjustment of his apparatus. Especial attention was given during the earlier years to points at high solar latitudes with a view to determining as accurately as possible the peculiar law of the sun's equatorial acceleration.

St. John's first results showed lower values of the radial motion at the solar edge and a longer rotation period than had been found by nearly all previous observers, and it was largely on this account that he decided to extend his observations over at least a full sun-spot cycle. At the end of an even longer period, however, the interpretation of the results still remains inconclusive. The observed velocities at the sun's limb after remaining low for several years, gradually began to increase and in 1934 reached nearly the values which earlier observers had found. But no certain correlation with the sun-spot cycle could be established. St. John recognized that at least a part of the change, which is definitely in evidence upon these photographs of spectra, is probably to be ascribed to scattered light in the apparatus. Whether any remaining difference represents a real variation in the sun's rotation period cannot as yet be decided. An important result of St. John's investigation was his confirmation of the higher angular velocities of rotation given by the lines of highest level in the sun's atmosphere.

The development and announcement of the theory of relativity interested St. John very greatly, and much of his later work was associated with the observational evidence for the validity of the equivalence principle of generalized relativity. In accordance with this principle solar and stellar spectrum lines should be displaced toward the red owing to the difference in gravitational potential between the gravitational field in which the emitting center is located and the terrestrial field where the radiation is received and measured. The displacement in the case of the sun when observed from the earth as calculated by Einstein amounts to 0.010 angstrom at $\lambda 5000$, a quantity well within the possibilities of observation.

St. John's first work on the relativity shift was based upon a group of lines in the so-called "cyanogen" fluting with its head at $\lambda 3883$ in the solar spectrum. These lines were selected be-

cause of their freedom from appreciable pressure shifts such as might complicate the problem under investigation. The results of measurement gave no definite evidence of the presence of the displacement required by the relativity theory, but soon afterward considerable doubt was thrown by new laboratory data on band spectra upon the quality and reliability of the lines used in the investigation. Accordingly, St. John undertook a much more extensive and elaborate study of the problem, which required several years and involved repeated measurements of more than 1500 lines. It reached its conclusion with an important paper published in 1928 entitled *Evidence for the Gravitational Displacement of Lines in the Solar Spectrum Predicted by Einstein's Theory.*

In this paper St. John discusses in detail the various causes of displacements of lines in the solar spectrum, including convection currents in the sun's atmosphere, differential scattering affecting the forms of the lines, and the "limb-effect." His final conclusion is that the predicted relativity shift is present in the sun in its full amount but that the effect of level is important. Lines at the center of the sun arising from medium levels give very closely the theoretical value, while those arising from high levels give somewhat more and those from low levels somewhat less than the predicted value. These differences he ascribes chiefly to the existence of radial convection currents near the photosphere the effect of which would, of course, vanish at the sun's limb. Several independent lines of evidence derived from both the sun and the stars add weight to the conclusion that such currents must exist. The important conclusions derived from this investigation, the care and skill in the discussion of the complex factors involved, and the extent of the material studied will doubtless make St. John's work on this problem a fundamental contribution to astrophysical knowledge.

Two interesting investigations on the planet Venus were carried on by St. John in collaboration with S. B. Nicholson in the years 1921-22. The first of these dealt with the problem of a possible "earth-effect" proposed by Evershed and Royds to account for differences observed by them between terrestrial

and solar wave-lengths, and pictured as an actual repulsion of the solar gases by the earth but not by other planets. Hence wave-lengths in the light from the earth-facing hemisphere of the sun should differ from those observed from a hemisphere facing, for example, the planet Venus. St. John and Nicholson collected a large amount of observational material when Venus was east and west of the sun and discussed their results both with reference to the angle Venus-Sun-Earth and the altitude of the planet. The measured values agreed in general with those obtained by Evershed and Royds, but the correlation of the displacements with the altitude of Venus seemed to be so definite that their origin was assigned to the conditions under which the observations were made rather than to any repulsive action from the earth.

A further investigation of the spectrum of Venus in the less refrangible region led to the important conclusion that the amount of oxygen in the part of the planet's atmosphere traversed by the reflected sunlight cannot exceed one-thousandth of that over equal areas in the earth's atmosphere. The amount of water vapor in the planet's atmosphere was also found to be very small. These observations have modified very considerably earlier views regarding the nature and composition of the atmosphere of this sister planet to the earth.

St. John's productive capacity during the years 1915-1925 was very high and his interests covered a wide range. In addition to the investigations already noted he made a valuable study of anomalous dispersion in the sun which proved the minor influence of this phenomenon upon solar observations; he undertook a detailed examination of the accuracy of measurement of close pairs of solar spectrum lines; in the physical laboratory he studied the pole effect in the electric arc and developed methods for its elimination; and he applied the results of his solar investigations to stellar spectra with marked success. All of this work was characterized by skill and resourcefulness in observational methods and unusual ability in the treatment and discussion of large quantities of numerical data.

The Revision of Rowland's Preliminary Table of Solar Spectrum Wave-Lengths was completed and published in 1928. In this extensive catalogue St. John, with the collaboration of Miss Moore, Miss Ware, E. F. Adams and H. D. Babcock, supplied one of the most important needs in astrophysics. The original Rowland Table published in 1896 was a work of extraordinary value and the relative wave-lengths of neighboring lines were remarkably accurate. The absolute wave-length of the standard upon which it was based was, however, considerably in error, and the method of coincidences used in the determination of wave-lengths and the adjustments applied to bring the solar and arc wave-lengths into agreement introduced irregularly distributed errors. St. John and his collaborators based their work upon the absolute wave-length of the red cadmium line, the most precise standard known, and a series of secondary and tertiary standards in the iron spectrum, the wave-lengths of which had been adopted by the International Astronomical Union. The wave-lengths of a large number of solar lines observed at the center of the sun and well distributed throughout the spectrum were then measured with reference to these standards, with the aid of both grating spectrographs and an interferometer. The comparison of the wave-lengths of these lines with those of Rowland's Table provided a series of correction curves of high precision by means of which the lines in the Table were corrected.

The Revised Table, in addition to giving accurate wave-lengths upon the International system, contains many corrections and additions to the old Table and much new material. The identification of great numbers of lines has been revised and many new identifications have been added, the behavior of lines in the sun-spot spectrum is noted and the temperature classification and the excitation potential have been listed wherever known. A supplementary table giving the solar lines in the infra-red portion of the spectrum between $\lambda 7333$, the limit of Rowland's Table, and $\lambda 10218$, the limit reached at the date of the Revised Table; lists of lines observed in the spectrum of the solar chromosphere and the corona; and catalogues of the

strongest unidentified lines and of term designations for the excitation potentials of lines investigated in the laboratory complete this useful volume. Its publication brought together the results and the applications of much of St. John's work over many years and serves as a permanent record of the industry and skill of the author.

In his later years St. John became greatly interested in the broad field of accurate photometry of spectral lines and commenced an extensive program which was but partially completed at the time of his death. This was a natural outgrowth of the years of work upon the Rowland Table of Solar Spectrum Wave-Lengths. Having contributed so greatly to precise measurements of position, he turned his attention to the other fundamental need—that of accurate determinations of intensity. Although he could not carry this work to completion, he published several brief papers dealing with its progress and developed methods of observation which are still in regular use at Mount Wilson.

In his scientific life St. John was a strong advocate of cooperative plans of investigation. He took a prominent part in the work of the International Astronomical Union, attended its meetings frequently, served as president of two of its scientific commissions and was a member of several others. He had a wide acquaintanceship with astronomers and physicists both in the United States and abroad and took great pleasure in the opportunities for discussion afforded by scientific meetings. A notable characteristic of his own scientific work was his desire to obtain the opinions of others and to consider the results of an investigation from as many points of view as possible.

On the personal side St. John had a remarkable ability to make friends and retain them, and some of his most intimate associations had extended over periods of nearly fifty years. His interest in people and in the life of the communities in which he lived was strong and active, and he took a prominent part in the establishment and support of social and cultural agencies of many kinds. Combined with his social instincts, however, were a great fondness for reading and a profound love

of nature which made his days of comparative isolation on the mountain top periods of the deepest pleasure and satisfaction. With his friendliness, enthusiasm and intelligent and accurate knowledge of nature he was a delightful companion at all times and under all circumstances. In the last years of his life, with a full knowledge of his physical condition, he faced the end with the same cheerfulness and courage which had characterized his philosophy of life throughout so many active and fruitful years.

BIBLIOGRAPHY

1887-1933

1887

(With William James Beal.) A study of Silphium perfoliatum and Dipsacus laciniatus in regard to insects. Bot. Gaz., vol. 12, 268-270.

1894

Wave-lengths of electricity on iron wires. Amer. Jour. Sci., vol. 48, 311-325.

Wave-lengths of electricity on iron wires. Phil. Mag., vol. 38, 425-441.

1895

Über die Vergleichung des Lichtemissionsvermögens der Körper bei hohen Temperaturen, und über die Auer'schen Brenner. Ann. Phys. Chem., vol. 56, 433-450.

Value of the magnetic permeability for rapid electrical oscillations. Phil. Mag., vol. 39, 297-298.

Wave-lengths of electricity on iron wires. Amer. Acad. Arts and Sci. Proc., vol. 30, 218-246.

1909

Note on the polarizing effect of coelostat mirrors. Astrophys. Jour., vol. 29, 301-304; Mt. Wilson Contr., No. 37.

1910

The absolute wave-lengths of the H and K lines of calcium in some terrestrial sources. Astrophys. Jour., vol. 31, 143-156; Mt. Wilson Contr., No. 44.

The general circulation of the mean and high-level calcium vapor in the solar atmosphere. Astrophys. Jour., vol. 32, 36-82; Mt. Wilson Contr., No. 48.

1911

Motion and condition of calcium vapor over sun-spots and other spectral regions. Astrophys. Jour., vol. 34, 57-78, 131-153; Mt. Wilson Contr., No. 54.

1912

(With L. W. Ware.) Tertiary standards with the plane grating: The testing and selection of standards. First paper. Astrophys. Jour., vol. 36, 14-53; Mt. Wilson Contr., No. 61.

1913

Radial motion in sun-spots. I. The distribution of velocities in the solar vortex. Astrophys. Jour., vol. 37, 322-353; Mt. Wilson Contr., No. 69.

Radial motion in sun-spots. II. The distribution of the elements in the solar atmosphere. Astrophys. Jour., vol. 38, 341-391; Mt. Wilson Contr., No. 74.

Radial motion in sun-spots. Read at 83d meeting B.A.A.S.; Rept. B.A.A.S., p. 392-394; Observatory, vol. 36, 395-397.

Sondage de l'atmosphere solaire par les mesures de vitesses radiales dans les taches. Comptes rendus, vol. 157, 428-430.

1914

The international standards of the second and third orders. Trans. Internat. Union for Cooperation in Solar Research, vol. 4, 74-78.

Radial motions in sun-spots. Trans. Internat. Union for Cooperation in Solar Research, vol. 4, 214-217.

(With L. W. Ware.) Tertiary standards with the plane grating: The testing and selection of standards. Second paper. Astrophys. Jour., vol. 39, 5-28; Mt. Wilson Contr., No. 75.

On the distribution of the elements in the solar atmosphere as given by flash spectra. Astrophys. Jour., vol. 40, 356-376; Mt. Wilson Contr., No. 88.

On pressure in the solar atmosphere. Read at 17th meeting, Amer. Astron. Soc.; Pubs. A.A.S., vol. 3, 95 (1918).

The distribution of the elements in the solar atmosphere from eclipse results. Read at 17th meeting, Amer. Astron. Soc.; Pubs. A.A.S., vol. 3, 94-95 (1918).

(With Harold D. Babcock.) A displacement of arc lines not due to pressure. Read at 72d meeting, Amer. Phys. Soc., Phys. Rev., Ser. 2, vol. 3, 487-488.

1915

Anomalous dispersion in the sun in the light of observations. Astrophys. Jour., vol. 41, 28-41; Mt. Wilson Contr., No. 93.

Critique of the hypothesis of anomalous dispersion in certain solar phenomena. Proc. Nat. Acad. Sci., vol. 1, 21-25; Mt. Wilson Communications, No. 2.

(With Harold D. Babcock). Pole effect in the arc and its relation to other investigations. Read at joint meeting of A.A.A.S. and affiliated societies.

(With Harold D. Babcock.) A study of the pole effect in the iron arc. Astrophys. Jour., vol. 42, 231-262; Mt. Wilson Contr., No. 106.

(With Harold D. Babcock.) Variability of spectrum lines in the iron arc. Proc. Nat. Acad. Sci., vol. 1, 131-136; Mt. Wilson Communications, No. 5.

(With Harold D. Babcock.) On the pole effect in the iron arc. Proc. Nat. Acad. Sci., vol. 1, 295-298; Mt. Wilson Communications, No. 4.

(With W. S. Adams and L. W. Ware.) Solar rotation in 1914-15. Read at 18th meeting. Amer. Astron. Soc.; Pubs. A.A.S., vol. 3, 136-137 (1918).

1916

(With L. W. Ware.) The accuracy obtainable in the measured separation of close solar lines; systematic errors in the Rowland table for such lines. Astrophys. Jour., vol. 44, 15-38; Mt. Wilson Contr., No. 120.

Observational evidence that the relative positions of Fraunhofer lines are not systematically affected by anomalous dispersion. Astrophys. Jour., vol. 44, 311-341; Mt. Wilson Contr., No.123.

The situation in regard to Rowland's preliminary table of solar spectrum wave-lengths. Proc. Nat. Acad. Sci., vol. 2, 226-229; Mt. Wilson Communications, No. 28.

On the suggested mutual repulsion of Fraunhofer lines. Proc. Nat. Acad. Sci., vol. 2, 458-461; Mt. Wilson Communications, No. 30.

The suggested mutual influence of Fraunhofer lines. Read at San Diego meeting, Pac. Div. A.A.A.S.; (Abstract) Pubs. A.S.P., vol. 28, 197.

(With L. W. Ware.) The measurement of close pairs of solar lines. Read at San Diego meeting, Pac. Div. A.A.A.S.; (Abstract) Pubs. A.S.P., vol. 28, 196.

(With L. W. Ware.) Systematic errors in the Rowland table for close pairs of solar spectrum lines. Read at 19th meeting, Amer. Astron. Soc. (1916); Pubs. A.S.P., vol. 3, 218-219 (1918).

On the mutual repulsion of solar spectrum lines. Read at 19th meeting, Amer. Astron. Soc. (1916); Pubs. A.A.S., vol. 3, 219-220 (1918).

Anomalous dispersion in the sun. Observatory, vol. 39, 462-465.

(With W. S. Adams.) The question of diffused light in Mount Wilson solar observations. Jour. R.A.S., Canada, vol. 10, 553.

1917

(With H. D. Babcock.) The elimination of pole effect from the source for secondary standards of wave-length. Astrophys. Jour., vol. 46, 138-166; Mt. Wilson Contr., No. 137.

The principle of generalized relativity and the displacement of Fraunhofer lines toward the red. Astrophys. Jour., vol. 46, 249-265; Mt. Wilson Contr., No. 138.

A search for an Einstein relativity-gravitational effect in the sun. Proc. Nat. Acad. Sci., vol. 3, 450-452; Mt. Wilson Communications, No. 46.

(With H. D. Babcock.) The development of a source for standard wave-lengths and the importance of their fundamental values. Proc. Nat. Acad. Sci., vol. 3, 505-507; Mt. Wilson Communications, No. 48.

(With H. D. Babcock.) Elimination of pole effect from secondary standards of wave-length. Read at Stanford meeting, Amer. Phys. Soc.; (Abstract) Phys. Rev., ser. 2, vol. 9, 577.

1918

(With L. W. Ware.) Notes on solar rotation. Read at 22d meeting, Amer. Astron. Soc. (1918) ; Pubs. A.A.S., vol. 4, 46-47 (1923).

Our nearest star, the sun. Pubs. A.S.P., vol. 30, 15-28.

The green corona line. Pubs. A.S.P., vol. 30, 250-251.

The present condition of the problem of solar rotation. Pubs. A.S.P., vol. 30, 319-325.

1919

(With H. D. Babcock.) Are the wave-lengths of the atmospheric absorption lines variable? Read at Pasadena meeting, A.S.P.; (Abstract) Pubs. A.S.P., vol. 31, 178.

(With L. W. Ware). On the source of discordant values for solar rotation. Read at Pasadena meeting, A.S.P.; (Abstract) Pubs. A.S.P., vol. 31, 186.

1920

The astronomical bearing of the theory of generalized relativity. Seattle meeting, A.S.P.; (Abstract) Pubs. A.S.P., vol. 32, 191.

The spectroscopic committee of The Division of Physical Sciences of The Research Council. Read at Seattle meeting, A.S.P.; (Abstract) Pubs. A.S.P., vol. 32, 192.

(With H. D. Babcock.) Concerning tables of solar wave-lengths in the International system. Read at Seattle meeting, A.S.P.; (Abstract) Pubs. A.S.P., vol. 32, 192.

(With S. B. Nicholson.) Relative wave-lengths of skylight and Venus-reflected sunlight. Read at Seattle meeting, A.S.P.; (Abstract) Pubs. A.S.P., vol. 32, 194.

(With S. B. Nicholson.) Determination of the solar parallax from spectroscopic observations of Venus. Pubs. A.S.P., vol. 32, 332-334.

Displacement of solar lines and the Einstein effect. Observatory, vol. 43, 158-162.

The displacement of solar spectral lines. Observatory, vol. 43, 260-262.

The spectroscopic committee of the Division of Physical Sciences of the National Research Council. Phys. Rev., vol. 16, 372-374.

1921

(With H. D. Babcock.) Wave-length of lines in the iron arc from grating and interferometer measures, $\lambda 3370$-$\lambda 6750$. Astrophys. Jour., vol. 53, 260-299; Mt. Wilson Contr., No. 202.

(With S. B. Nicholson.) On systematic displacements of lines in spectra of Venus. Astrophys. Jour., vol. 53, 380-391; Mt. Wilson Contr., No. 208.

(With S. B. Nicholson.) On the absence of selective absorption in the atmosphere of Venus. Read at Berkeley meeting, A.S.P.; Pubs. A.S.P., vol. 33, 208-209.

The displacement of solar lines. Nature, vol. 106, 789-790.

(With S. B. Nicholson.) The spectrum of Venus; no oxygen or water-vapor lines present. Read at Swarthmore meeting, Amer. Astron. Soc. (1921); (Abstract) Pop. Astron., vol. 30, 229 (1922); Pubs. A.A.S., vol. 4, 326-327 (1923).

Increased ionization over solar faculae. Read at Swarthmore meeting, Amer. Astron. Soc. (1921); (Abstract) Pop. Astron., vol. 30, 228-229 (1922); Pubs. A.A.S., vol. 4, 326 (1923); Toronto meeting, Amer. Phys. Soc. and A.A.A.S. (1921); (Abstract) Phys. Rev., vol. 19, 390 (1922).

(With S. B. Nicholson.) The physical constituent of the atmosphere of Venus. Toronto meeting, Amer. Phys. Soc. and A.A.A.S. (1921); (Abstract) Phys. Rev., vol. 19, 444 (1922).

1922

(With H. D. Babcock.) An investigation of the constancy in wave-length of the atmospheric and solar lines. Astrophys. Jour., vol. 55, 36-47; Mt. Wilson Contr., No. 223.

(With S. B. Nicholson.) The absence of oxygen and water-vapor lines from the spectrum of Venus. Astrophys. Jour., vol. 56, 380-399; Mt. Wilson Contr., No. 249.

(With S. B. Nicholson.) Further observations on the spectra of Venus. Read at Williams Bay meeting, Amer. Astron. Soc. (1922); (Abstract) Pubs. A.A.S., vol. 4, 385-386; Pop. Astron., vol. 31, 24-25 (1923).

Remarks on testing the Einstein theory by displacements of solar lines. Centenary celebration of R.A.S.; Observatory, vol. 45, 210-212.

Remarks on ionization over faculae. Brit. Astron. Assoc. meeting; Observatory, vol. 45, 214.

On the spectra of Venus and Miller's repetition of the Michelson-Morley experiment. Colloquium at the Istituto Fisico, Rome.

Bemerkung zur Rotverschiebung-Physikalische Zeitschrift, vol. 23, 197.

Solar faculae and ionization. Contr. Jefferson Phys. Lab., vol. 15.

1923

The atmosphere of the sun and relativity. (Abstract) Pubs. Amer. Astron. Soc., 30th meeting, Mt. Wilson, 84-86 (1923); Pop. Astron., vol. 32, 23-25 (1924).

1924

(With Walter S. Adams.) Convection currents in stellar atmospheres. Astrophys. Jour., vol. 60, 43-49; Mt. Wilson Contr., No. 279.

(With Harold D. Babcock.) Pressure and circulation in the reversing-layer of the sun's atmosphere. Astrophys. Jour., vol. 60, 32-42; Mt. Wilson Contr., No. 278.

(With Walter S. Adams.) Convection currents in stellar atmospheres. Proc. Nat. Acad. Sci., vol. 10, 392-394; Mt. Wilson Communications, No. 89.

(With Walter S. Adams and Harold D. Babcock.) On pressure and convection currents in the atmospheres of the sun and stars. (Abstract) Pubs. Amer. Astron. Soc., vol. 5, 32d meeting, Dartmouth, 191; Pop. Astron., vol. 32, 621-622.

(With Harold D. Babcock.) Note on the pressure and currents in the sun's atmosphere. Proc. Nat. Acad. Sci., vol. 10, 389-391; Mt. Wilson Communications, No. 88.

1925

(With Walter S. Adams.) An attempt to detect water-vapor and oxygen lines in the spectrum of Mars with the registering microphotometer. (Abstract) Pubs. A.S.P., vol. 37, 158-159.

Rotation of the sun. (Abstract) Pubs. Amer. Astron. Soc., vol. 5, 34th meeting, Northfield, 290-291; Pop. Astron., vol. 33, 592-593.

Report of the Commission on Solar Physics. Trans. Internat. Astron. Union, vol. 2, 27-39.

1926

The red shift of solar lines and relativity. Proc. Nat. Acad. Sci., vol. 12, 65-68; Mt. Wilson Communications, No. 96.

(With Walter S. Adams.) An attempt to detect water-vapor and oxygen lines in the spectrum of Mars with the registering microphotometer. Astrophys. Jour., vol. 63, 133-137; Mt. Wilson Contr., No. 307.

1927

Revision of Rowland's Preliminary Table of Solar Spectrum Wave-lengths. Proc. Nat. Acad. Sci., vol. 13, 678-683; Mt. Wilson Communications, No. 101.

Revision of Rowland's Preliminary Table of Solar Spectrum Wave-lengths. Read at Reno meeting, A.S.P.; (Abstract) Pubs. A.S.P., vol. 39, 256-257.

(With Charlotte E. Moore.) As to cadmium in the sun. Pubs. A.S.P., vol. 39, 314-317.

1928

Astrophysical importance of the rare-earth elements. Read at Berkeley meeting, Amer. Phys. Soc.; (Abstract) Phys. Rev., vol. 31, 918-919.

Evidence for the gravitational displacement of lines in the solar spectrum predicted by Einstein's theory. Astrophys. Jour., vol. 67, 195-239; Mt. Wilson Contr., No. 348.

Some results of the revision of the Rowland table. Read at Pomona meeting, A.S.P.; (Abstract) Pubs. A.S.P., vol. 40, 270-271.

(With Charlotte E. Moore.) On the presence of the rare-earth elements in the sun. Astrophys. Jour., vol. 68, 93-108; Mt. Wilson Contr., No. 364.

(With Charlotte E. Moore, Louise M. Ware, Edward F. Adams, and Harold D. Babcock.) Revision of Rowland's preliminary table of solar spectrum wave-lengths, with an extension to the present limit of the infra-red. Carnegie Inst. Pub. No. 396; Papers of the Mt. Wilson Observatory, vol. 3, pages xxi + 238.

1929

Growth in our knowledge of the sun. Pubs. A.S.P., vol. 41, 133-144.

Report of the Commission de Physique solaire. Trans. Internat. Astron. Union, vol. 3, 5076.

Elements unidentified or doubtful in the sun: suggested observations. Astrophys. Jour., vol. 70, 160-174; Mt. Wilson Contr., No. 385.

The unit character of multiplets. Astrophys. Jour., vol. 70, 312-318; Mt. Wilson Contr., No. 389.

Excitation potential in solar phenomena. Astrophys. Jour., vol. 70, 319-330; Mt. Wilson Contr., No. 390.

Elements in the sun. Proc. Nat. Acad. Sci., vol. 15, 789-793; Mt. Wilson Communications, No. 107.

Elements: Identified and unidentified in the sun. Read at Berkeley meeting A.S.P.; (Abstract) Pubs. A.S.P., vol. 41, 267-269.

1930

The Einsteinian displacement of spectral lines. Read at Eugene meeting, A.S.P.; (Abstract) Pubs. A.S.P., vol. 42, 254.

Growth in our knowledge of the sun. Smithsonian Report for 1930, 177-189 (1931); reprinted from Pubs. A.S.P., vol. 41, 133-144 (1929).

1932

Variability of solar rotation. Third Report of Commission Appointed to Further the Study of Solar and Terrestrial Relationships, 116-122.

Observational basis of general relativity. Pubs. A.S.P., vol. 44, 277-295.

1933

Report of Commission de Physique solaire. Trans. Internat. Astron. Union, vol. 4, 34-57.

C H Eigenmann

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OF

CARL H. EIGENMANN
1863–1927

BY

LEONHARD STEJNEGER

PRESENTED TO THE ACADEMY AT THE ANNUAL MEETING, 1937

CARL H. EIGENMANN *

1863–1927

BY LEONHARD STEJNEGER

Carl H. Eigenmann was born on March 9, 1863, in Flehingen, a small village near Karlsruhe, Baden, Germany, the son of Philip and Margaretha (Lieb) Eigenmann. Little is known of his ancestry, but both his physical and his mental characteristics, as we know them, proclaim him a true son of his Suabian fatherland. When fourteen years old he came to Rockport, southern Indiana, with an immigrant uncle and worked his way upward through the local school. He must have applied himself diligently to the English language and the elementary disciplines as taught in those days, for two years after his arrival in America we find him entering the University of Indiana, bent on studying law. At the time of his entrance the traditional course with Latin and Greek still dominated, but in his second year in college it was modified, allowing sophomores to choose between Latin and biology for a year's work. It is significant that the year of Eigenmann's entrance was also that of Dr. David Starr Jordan's appointment as professor of natural history. The latter had already established an enviable reputation as an ichthyologist, and had brought with him from Butler University several enthusiastic students, among them Charles H. Gilbert who, although only twenty years of age, was associated with him in preparing the manuscript for the "Synopsis of North American Fishes," later published as Bulletin 19 of the United States National Museum. Eigenmann's teacher in the classic curriculum is said to have been "uninspiring" so it is small wonder that when the choice came to his students, the best ones took advantage of the opportunity to follow the new trend, and as Jordan tells us "the leader of these, Carl H. Eigenmann, found in Zoology the passion of his life." Realizing that

*According to Dictionary of American Biography, "Eigenmann's middle initial did not stand for a name."

"his work was of the highest order" Jordan later made him instructor in his department.

This was a period of great activity in American vertebrate systematic taxonomy and faunistic studies, which has rightly been called the Bairdian Period, beginning with the reports on the zoological collections of the Pacific Railroad Surveys and the Mexican Boundary Commission, with headquarters at the Smithsonian Institution under Spencer Fullerton Baird. At that time there was gathered in Washington a circle of specialists such as Gill, Tarleton Bean, Brown-Goode, Ridgway, Dall, True, Coues and others with whom Jordan was in close cooperation.

The zoology of these men and zoology as it was taught at the Indiana University at that time, is now referred to as taxonomy and zoogeography. Jordan defined taxonomy as "technical classification of organisms—an attempt to express as well as possible by different categories (order, family, genus, species) the lines of descent and ramification through which animals and plants have acquired their present forms. A classification truly natural—that is, based on structure, embryological development, geological history, and genetic descent—is a transcript of our actual knowledge of the evolution of the forms in question. From this point of view, taxonomy is the perfected product of all Natural History research." Jordan's method was to take up one of these categories, the species of a genus, or the genera of a family, for study with the student and embody the results in a paper under their joint authorship, or to turn the material over to the student to be worked up alone or jointly with another student. Thus in taking up the study of the darters with a view to ascertaining their relationship to the true perches, he had Eigenmann prepare skeletons of 20 species of the subfamily *Etheostomatinae*. The result of their studies was embodied in a joint paper concluded in March 1885 and published in the Proceedings of the National Museum, Eigenmann's first publication the year before he received his bachelor's degree. Now followed in quick succession numerous papers by the young ichthyologists. In 1885 they submitted no less than fourteen

papers to the Philadelphia Academy of Natural Sciences, and Jordan, either alone or jointly with Eigenmann, Gilbert, Meek, or Hughes, submitted to the United States National Museum fourteen papers on fishes. Among Eigenmann's papers of that year may be mentioned his first "Review" paper, in conjunction with Morton W. Fordice, giving full "synonymy of the genera and species of the *Eleotridinae* found in the waters of America with analytical keys by which they may be distinguished," based on specimens belonging to the University of Indiana mostly collected by Professor Jordan.

Before the end of the year Eigenmann finished another similar paper on the *Diodontidae,* Porcupine-fishes, which was published the following year over his own name only. In this early paper the 23-year old ichthyologist demonstrated the painstaking, careful, deliberate qualities which distinguish all his later work. The object of the investigation was "to ascertain the number and valid species and their correct nomenclature" the main problem before him being the question of the distinctness of the two Linnean species *Diodon hystrix* and *holocanthus.* Point for point he analyzed the literature, quoting it *verbatim;* point for point he examined the whole series of specimens by number and origin, so that his statement can be verified and used by future investigators. He found gaps and uncertainties both in the literature and in the material, yet although he had become fairly convinced that the two forms were identical, he was satisfied with leaving them separate for the time being. No hasty judgment, no juvenile self-assertion, no dogmatic insistence on his own view! It is interesting to note that he acknowledged himself "indebted to Miss Rosa Smith for the description of two specimens from La Paz, at San Diego."

An interesting side of Eigenmann's mental activity at this time is revealed in a little sketch entitled "Folk-lore of a German Village" in *The Current* of May 1, 1886, a Chicago weekly, in which he not only tells a charming story of the reported origin of the names of his own native village and of the neighboring Sickingen, but through some Suabian folklore about death and

Faust is led into a discussion of the latter, revealing considerable familiarity with the literature.

Eigenmann received his bachelor's degree in 1886. In the fall, Dr. Myers tells us, an opportunity for the principalship of a school in Santa Paula, California, came to him through his classmate, Barton W. Evermann. He arrived too late for the position but remained for a while in the state. In San Diego he met Miss Rosa Smith, who was already becoming known as a competent ichthyologist by her papers on west coast fishes. They were married in that city on August 20, 1887, and thus was started under joint authorship that series of ichthyological papers which soon made the "Eigenmann and Eigenmann" authority familiarly known on two continents. The opportunity had come for the newlyweds to attend Harvard University and under Alexander Agassiz, Garman and Mark to study the large collections of fishes gathered by Louis Agassiz and his assistants during the Thayer Expedition in Brazil, and by Alexander Agassiz and Dr. Steindachner during the Hassler Expedition around South America. Having received his master's degree at Bloomington, Eigenmann and his wife were soon at work at the Museum of Comparative Zoölogy, Cambridge, Massachusetts, and with short intervals there appeared a series of important papers along two distinct lines, some on embryological and evolutionary subjects, others on faunistic or purely taxonomic questions, too numerous to be specified here, but the appearance of their first report on the South American fishes, the precursor of the many later publications which were the crowning success of Eigenmann's life work, shall be mentioned.

The "Preliminary Notes on South American *Nematognathi*" or Catfishes, was issued as early as July 18, 1888, an impressive paper of 52 pages treating of 296 species, 36 of which were described as new, belonging in 61 genera and 5 families. Practically simultaneously there appeared in the *American Naturalist* an article giving a key to the families and showing that the enclosure of the airbladder in a bony capsule in the *American Nematognathi* is the rule rather than the exception. There can be no doubt that the year spent at Harvard, with a brief summer

course at Woods Hole was of the utmost importance in molding Eigenmann's scientific individuality. While greatly taken up with taxonomic studies of the South American fish fauna, he was assiduously pursuing those other zoological disciplines which were to become his main working field for the next ten years.

By the middle of December 1888 the Eigenmanns were back in San Diego, where as curator of the local Natural History Society he was instrumental in establishing the San Diego Biological Laboratory. The fishes of the coast became the immediate objects of Eigenmann's investigations but not merely from the purely systematic standpoint. The study of variation was one of the principal lines of research laid out in establishing the station, but the life histories, development and evolution of the San Diego fishes were receiving equal attention, as demonstrated in the paper entitled "Fishes of San Diego" published by the United States National Museum in 1892. Besides the purely taxonomic matter, this article contains his observations on the spawning habits and seasons, the embryology and migrations of the fishes of southern California. Among many important contributions it also contains a full account of the development of the Point Loma blind fish, *Typhlogobius californiensis,* with the promise of a minute description of the eye to follow. This is noteworthy from the fact that when Mrs. Eigenmann guided him to the blind fish rock at the base of Point Loma, according to his own statement, the first definite plans for the study of evolution by degeneration took hold of him.

Perhaps the most important work done by Eigenmann on the Pacific Coast was his contribution to the ontogeny of viviparous fishes based on the study of *Cymatogaster aggregatus,* and when the final paper was published in 1894 in the Bulletin of the United States Commission of Fisheries for 1892 (98 pages, 27 plates) it was at once recognized as an outstanding achievement.

However, the problems of the South American fish fauna were not abandoned. The elaborate review of the catfishes, *Nematognathi* (508 pp.) was finished and published in July 1890 by the California Academy of Sciences with which both

Eigenmanns had become closely associated. The various problems were being worked out and embodied in a comprehensive "Catalogue of the Fresh-water Fishes of South America" which was published in July 1891. It enumerates 1135 specific names under 240 genera, but in addition under separate headings discusses the peculiarities of the South American fauna, its origin and its geographical distribution, representing a summary of all that was known of the fauna up to that time. Realizing the inadequacy of the material in museums and the necessity for studying the territory in person, Eigenmann hoped to take the field himself and had planned a trip of exploration to Colombia in 1891, but other events intervened and compelled the relegation of such plans to an indefinite future.

The University of Indiana conferred the degree of Doctor of Philosophy on Eigenmann in 1889, and when in 1891 Jordan was called to Stanford University as its first president, he appointed Eigenmann professor of zoology at Bloomington.

With characteristic energy Eigenmann took hold of his new duties. With many of his contemporaries he realized the inadequacy of merely descriptive taxonomy as practically the only university discipline in zoology. As he himself put it, they had "ceased to content themselves with the cataloguing of specimens" and were now to "study the method, whys and wherefores of the things about them." On the other hand, studies, the materials for which were reasonably near at hand, would have to be devised, and the study of the variation, development and evolution of the species composing the local fauna suggested itself. He consequently became a zealous promoter and director of the Biological Survey of Indiana established in 1892 by the Indiana Academy of Sciences, and in 1899 he supplemented it by the establishment of the biological freshwater station at Turkey Lake, northern Indiana (later removed to Winona Lake). Naturally fishes retained their status as the principal material for study, and located as the station was, an intimate knowledge of the freshwater fish fauna of both the east-flowing and west-flowing river systems of the whole continent became of the utmost importance.

As early as 1892 Eigenmann was in the field, making a comparative study of the fishes of the Pacific and Atlantic slopes. The trip extended from Winnipeg to Vancouver and from Oregon to Montana, and during August and part of September he covered the headwaters of the Red River of the North, the Saskatchewan, the Columbia, the Fraser River and the Missouri. The trip was financed by Dr. Günther as a collecting expedition for the British Museum but the results were published in the Bulletin of the United States Fish Commission for 1894. The number of species collected was 65, about 20 per cent of which were new.

Another field of research was beckoning almost at the very door of his laboratory, viz. the complex of Indiana caves with their blind inhabitants. The interest awakened in him by his studies of the Point Loma blind fish now spurred him on. One of his earliest discoveries greatly encouraged further research. Eigenmann found that the blind fish which inhabits the underground waters of western Missouri and which had previously been regarded as identical with the one long known from the Mammoth Cave in Kentucky, was not only a different species, but that it represented a distinct genus with an epigean ancestry different from that of the Mammoth Cave *Typhlichthys.* He named it *Troglichthys rosae* after his wife "the re-discoverer of the California *Typhlogobius*." But his researches were not limited to the fishes. In the nineties of the last century several sensational discoveries of blind cave salamanders were made, *Typhlotriton* in Missouri, and *Typhlomolge* in Texas, which attracted Eigenmann's attention. Even the blind woodrat of the Mammoth Cave was included in his investigations. Numerous excursions were undertaken during these years, exploring caves and underground water courses. As a result "a veritable stream of papers by himself and his students issued from the laboratory in Bloomington" during the next decade.

Eigenmann's intensive studies of "degenerate evolution" of the vertebrates were now attracting the attention of the scientific world. Grants from the Elizabeth Thompson Science Fund and the American Association for the Advancement of Science

enabled him to extend his excursions in search of material to Missouri, Texas and Kentucky. In 1902 through a grant from the Association he was able to visit the blind fish caves of Cuba and subsequently the Carnegie Institution of Washington made it possible for him to make additional investigations in Cuba. Accompanied by students and volunteer assistants he made several visits to the island between 1902 and 1904 and succeeded in gathering females both of *Lucifuga* and *Stygicola* with young.

During the winter 1906-1907 we find him in Europe attending the lectures of Weissmann and of Wiedersheim at the University in Freiburg. At the Anatomical Institute Professor Wiedersheim placed his laboratory at Eigenmann's disposal for his studies of the eyes of the cave vertebrates and there he had the drawings made which later appeared in his monograph. The discussions and close contacts with these men could not be without great influence on the development of his own theories on heredity and evolution.

The researches on the cave faunas came to a conclusion with the publication in 1909 by the Carnegie Institution of Washington of the splendid quarto volume "Cave Vertebrates of North America, a study of degenerative evolution." As "conclusions of general import" he prefaced it by the following statement: "(1) The bleached condition of animals living in the dark, an individual environmental adaptation, is transmissible and finally becomes hereditary, fixed. (2) Ornamental secondary sexual characters not being found in blind fishes are, when present, probably due to visual selection. (3) Individual degeneration of the eye may begin in even earlier stages of development until nearly the entire development becomes affected, that is, functional adaptations are transmissible."

During his trip to Europe, Eigenmann also visited the museums in London, Paris and Vienna for the particular purpose of examining type specimens of South American freshwater fishes, for in spite of all the busy university work and the exploration of the caves, he had not entirely laid aside nor forgotten his first love, the study of the neotropical fish fauna, though it naturally was kept in the background. However, in 1903 he

resumed work on the Brazilian *Characidae* based upon the collections of the Indiana University and of the United States National Museum, a monograph being actually completed in 1906. The following year the study of the Thayer Expedition collections in the Museum of Comparative Zoölogy was renewed, with the result that the entire monograph had to be rewritten. During this work, however, it became apparent that plentiful as was the material for the time and the region covered by the early explorers, it was not sufficient for a really fundamental work such as Eigenmann had intended it to be.

As early as 1904 he began agitating for a biological survey of the Panama region by the Smithsonian Institution. Dr. Rathbun expressed sympathy with the idea and the purpose of "a complete natural history investigation." Requests that the authorities in charge of the construction of the Panama Canal organize such a survey fell on deaf ears, but Eigenmann did not lose courage. On his initiative, the American Microscopical Society in 1905 passed a resolution urging the survey, and a similar resolution was introduced by the section of zoogeography to the general session of the International Zoological Congress at Boston in 1907, and was passed unanimously. The reasons for such a survey were stated as follows: "It is certain that the Pacific slope fresh-water fauna of South and Middle America was derived from the Atlantic slope fauna. The Isthmus of Panama is one of the possible routes of migration. The Panama Canal, when completed, will destroy natural barriers and cause the faunas of the two slopes to mingle to a great extent. It will thus permanently obliterate the natural and primitive conditions, and it is highly desirable that a biological survey of this region be made before the completion of the canal."

At the next meeting of the American Association for the Advancement of Science in December of the same year, the resolution adopted was addressed directly to the President and Congress urging that provision be made for such a survey. Three years later it was announced that with the approval of President Taft the plan would be carried out by cooperation of such Government agencies as the Bureaus of Fisheries, Biolog-

ical Survey, Entomology, etc., under the direction of the Smithsonian Institution. Although the result of his initiative and energetic agitation, Eigenmann was not to take an active part in its field work as in the interim of the long delay he had formed other connections.

At the reorganization of the graduate school of Indiana University in 1908, Eigenmann was made its dean and relieved of his teaching duties when needed for field work and the preparation of reports.

In 1907 arrangements had been made for one of Eigenmann's former students, John D. Haseman, to go to South America on a collecting expedition for the Carnegie Museum at Pittsburgh. Between November of that year and January, 1910, he brought together a very large series of South American fresh-water fishes, mostly from areas not covered by the Thayer Expedition.

Eigenmann had for some time been working with a collection of fishes brought back by the Princeton University Expeditions to Patagonia, and in preparing the report had been led into a discussion of von Ihering's Archhelenis theory of a former land-connection between South America and Africa. The Guiana ichthyic province was supposed to have been part of this connection, and as he found indications in the literature that the fish fauna of the lowlands differed from that of the table land of Guiana, where remnants of the original fauna might be expected to persist, he considered it necessary that the rivers of that region "should be explored *above* and *below* falls that are impassable barriers for the ascent of fishes." Having made this suggestion it was quite natural that he should desire to undertake this suggestion himself if arrangements could be made.

In the summer of 1908, having been refused assistance by various institutions he started on his own resources accompanied by Mr. E. S. Shideler as volunteer assistant, but visiting Dr. Holland at Pittsburgh on the way out he obtained the latter's pledge that the Carnegie Museum would help. He arrived in Georgetown on September 6 during the dry season when the upper portions of the rivers are lowest and the fishes consequently concentrated in the channels of the streams. His object

in undertaking the expedition was a double one, best stated in his own words: "First to observe, photograph and incidentally collect as many species as possible for my monograph of the characins; second, in connection with my general faunal study of the fishes of South America to determine, if possible, the relation of the fish fauna of the Guiana plateau to that of the lowlands, more particularly the relationship existing between the faunas of the upper and the lower Potaro." Another quotation will illustrate some of Eigenmann's personal characteristics and methods which contributed to his success:

"If seeing and recording a lot of 'specimens' which have been disintegrating for longer or shorter periods in alcohol can be called acquaintance, I have been acquainted with South American fresh-water fishes for many years. In contrast to such an acquaintance I recall standing one exciting morning on the brink of a small pool, which my Indians said contained fishes. It was not more than fifty feet across and was back-water left by the receding Essequibo. The Indians pounded poisonous hiari roots, tied them into bundles, and the boys then swam through the pool with them over their backs and thus mixed the poison. Soon one species, then another, and still others which I had only known as mummies, were resurrected from the depths of that pool and I danced about its margin with delight to see them in their living vivid colors and incidentally to embalm them in their turn for future reference . . . I do not know how long we stayed there, not over two hours, in which we caught fifty-five different species of fishes, six of which were not secured elsewhere."

Notwithstanding the fact that Eigenmann was taken ill with a fever, the trip was a huge success. He was back in Georgetown before the middle of November and arrived in New York with an unprecedented collection of about 25,000 specimens. Of these 18,300 odd specimens represented the ichthyic fauna of the area covered by the expedition, furnishing an enormous amount of material for most intensive work during the next couple of years. Apart from the general conclusions drawn from the study of the collection and the suggestions for the conduct of future expeditions, the trip yielded 28 new genera and 128 new species.

The following years were devoted to reports on the Guiana collection and others. Several important works finished earlier were published in 1909. "The Cave Vertebrates of North America," already alluded to, was followed three days later by his equally important "Fresh-water Fishes of Patagonia and an examination of the Archiplata-Archhelenis Theory" in volume 3 of the Reports of the Princeton University Expeditions to Patagonia, 1896-1899.

In this report which was practically finished in 1906, after showing that the fish fauna of the Archiplata, or Patagonia, is not related to the typical American fishes, he defined four main "regions" of unequal value of Middle and South America, viz. the Transition, the Mexican, the Andean and the Brazilian regions. The Brazilian region is again divided into 10 "provinces." He then discusses the origin of these different faunas based on detailed lists of species giving their geographical distribution. The Archhelenis theory is treated in a special chapter entitled "The Necessity and Evidence of a Former Land Connection between Africa and South America" (p. 363 *seqv.*). After noting that the "North American fauna is entirely distinct from the tropical American fauna" he analyzes the constituents of the two groups of families which Tropical Africa and Tropical South America have in common. One by one he discusses the availability of each family as proof of a hypothetical land connection. Some of them he rejects outright as of recent marine origin; the distribution and relationship of others, he finds, do not absolutely require a land connection to account for their presence in both continents though "such a connection would be very convenient." But when he comes to the *Cichlidae* and *Characidae* he reaches the conclusion that "there is no known means by which these two forms could have crossed the existing gap between Africa and South America. There has been no exchange of species in recent times, for there is no species or genus common to the two continents. The South American and African elements of these two families must have been derived from some intermediate land-mass or must have gone from one continent to the other over a land bridge." He argues

further that this land connection which he regards as "imperative" must have been obliterated before the Tertiary, before the origin of existing genera and before many of the existing families.

He winds up with a statement in which we clearly discern a well planned program which he had already laid for his future work. As such it merits to be quoted in full: "The points of strategic importance for ichthyic chorology in South America are, therefore, (*a*) western Colombia and Panama; (*b*) Guayaquil and Peru to the Amazon, across the Andes; (*c*) the table land of Guiana, Archiguiana; (*d*) the Rio San Francisco, with the Rio Parahyba and the headwater of the Tieté and Rio Grande, in Archamazona; and (*e*) the area between the Rio Negro and the La Plata."

It will be noted that this was written in 1906 before his expedition to Guiana and that consequently point *c* was already carried out before the program was published.

The connection established with the Carnegie Museum in Pittsburgh was tightened after his return from Guiana by Eigenmann being made an honorary curator of fishes in the Museum, though still residing in Bloomington—a position he held until 1918. There thus fell under his immediate charge the great collection of South American fishes made by Haseman, already alluded to. The working up of this and the Guiana spoils occupied the next couple of years and required a second visit to Europe in the summer of 1910 to examine types in the museums in London, Leiden, Amsterdam, Berlin, Vienna, and Paris during which he established most cordial relations with the leading ichthyologists abroad.

By 1912 he was again in the field, this time in an attack on point *a* of his program, viz. "western Colombia and Panama." Panama, it will be remembered, had already been covered by the Smithsonian Institution. Eigenmann, therefore, in order to carry the work southward arrived at Cartagena, Colombia, on January 3, 1912. The route of the expedition was up the Magdalena River to Girardot, from where a side trip was made to Bogotá. From Girardot the Cordillera was crossed by pack

train, eventually reaching the upper Atrato River and the party was back in Cartagena on April 2. The collection was acquired by the Carnegie Museum. The Colombia collections were supplemented at the end of the year by a trip of two Indiana University undergraduates financed by two Indianapolis gentlemen. One of them was enabled to continue all through 1913 and part of 1914, extending his collecting excursions into Ecuador.

The world war period was passed in writing and publishing either alone or jointly with students, numerous papers on South American fishes, notable reviews of peculiar families. But most important was the appearance in 1917 and 1918 of the first two parts of his *magnum opus,* the monograph "The American Characidae" in the Memoirs of the Museum of Comparative Zoölogy. Begun, as we have seen, by the newly-wed Eigenmanns in Cambridge in 1888, resumed in 1903 at Bloomington, manuscript finished in 1906, rewritten and partly finished in 1908, it was postponed in anticipation of additional material in order to satisfy the author that his work might be so fundamental that his conclusions would remain unassailable. These first installments included six subfamilies embracing 52 genera and 312 species, one-half of which were described as new during the preparation of the work, and accompanied by 38 plates splendidly illustrating this unique fauna. I call special attention to plate 1, which is a map of South America showing the routes of his predecessors in the exploration of the South American fish fauna, not only because it is of great help to students in other special fields, but chiefly because it demonstrates Eigenmann's strong geographic sense which renders his work so trustworthy and so helpful.

But his program for the survey was as yet only partly carried out, and much more material was needed. In 1918, heading the expedition made possible by the generosity of the Hon. Will J. Irwin under the auspices of the Universities of Indiana and Illinois and aided by grants of the National Academy of Sciences from the Bache Fund and of the American Association for the Advancement of Science, Eigenmann, accompanied by his daughter Adele, medical student of the University of Indiana

and by Mr. W. R. Allen, a traveling fellow of the University of Illinois, started in June by way of New Orleans, where the expedition was delayed five weeks waiting for passports from Washington, a postlude to the war—Eigenmann was born in Germany!—only ended by a direct appeal to President Wilson. The high Andes of Peru were first visited, where collections were made in the rivers and lakes reaching elevations up to 15,900 feet. They also visited La Paz in Bolivia and Mr. Allen surveyed Lake Titicaca from December to May. In February, 1919, Eigenmann went south to Chile where he was disappointed at the paucity of the fresh-water fish fauna of only 30 odd species belonging to 10 families. On the first of June, 1919, he returned. As usual he brought back with him a large and varied material the study of which resulted in important publications. According to Myers[1] "it was on this trip that the strain of the great altitudes broke the indomitable strength of Eigenmann, once before weakened by fever in Colombia and it is from this time that we must mark his decline in health."

He had now completed the Pacific slope portion of his program with the exception of a few rivers in Peru and Chile, which as late as March 4, 1921 he still hoped to be able to visit. His field days were over and the exploration of the Atlantic slope he had to leave to others, but he had shown the way, he still had the enthusiasm and he saw to it that younger men carried on the work. Thus in 1920 he was instrumental in sending William R. Allen (Centennial Expedition of the University of Indiana) to the upper reaches of the Amazon, followed in 1921 by Nathan E. Pearson (of the Mulford Expedition). The last collection of importance was that of Dr. Carl Ternetz who from 1923 to 1925 traveled down the Rio Tocantins to the Amazon and up that river to Manáos, ascended the Rio Negro and finally crossed over to the Orinoco. According to competent authority his collections "richer than any brought from South America since those of the Agassiz Expedition and possibly even surpassing them" came to Bloomington.

[1] Nat. Hist., vol. 28, 1928, p. 100.

The work in the laboratory and museum continued, however, unabated, and reports on the expeditions making public the preliminary results of the work appeared within short intervals mostly in the "Indiana University Studies." Some of his more detailed and fundamental volumes were also published at this time, for instance in July 1921, part 3 of "The American Characidae" (100 pp. + 28 plates) and in January 1923 "The Freshwater Fishes of Northwestern South America" (346 pp. + 38 plates and maps), the latter issued by the Carnegie Museum. At the symposium on geographical distribution of the American Society of Zoologists, the American Society of Naturalists and the Ecological Society of America, at Cambridge, December 1922, Eigenmann participated with a summary of his South American work, entitled "The Fishes of the Pacific Slope of South America and the Bearing of their Distribution on the History of the Development of the Topography of Peru, Ecuador and Western Colombia" in which he presents some of his general conclusions. On the Pacific slope between Panama and southern Chile there are two main faunas. That of Chile belonging to the south temperate Patagonian fauna is poor in species. The fishes north of Lima pertain to the Amazon-Orinoco and Central American fauna with but a few occasional north temperate "surprises," 385 species having been taken in this area which is divisible into several distinct regions. The highland fauna (above 7000 feet) in part overlaps the different lowland faunas.

Besides the great family of the Characidae, Eigenmann had from time to time finished and published monographs of some of the smaller families of the South American Catfishes, and even as late as 1925 the American Philosophical Society in its Transactions published his Review of the Doradidae (86 pp. + 27 plates) in which he was able to utilize material collected by Pearson during the Mulford Expedition.

The completion of the monograph on the American Characidae, however, was evidently a long way off, but he worked at it as long as his strength would permit, and then he called in younger help which he hoped might complete it. Dr. G. S.

Myers was selected and with his assistance the manuscript for parts 4 and 5 was finished in the summer of 1925, but he did not live to see them published. The "Fresh Water Fishes of Chile" published by the National Academy of Sciences as one of its Memoirs (vol. 22, Mem. 2, 63 pp. + 16 plates) in 1927 also appeared after his death.

The elimination of yellow fever by means of fishes eating the larvae of mosquitoes had interested him for many years and the studies of their habits and distribution was of great assistance when in later years his advice was sought by the authorities charged with the work of freeing the South American countries of the pest, and as late as April 1924 we find him presenting a suggestive paper on "Yellow Fever and Fishes in Colombia" to the Philosophical Society.

But Carl Eigenmann's working days had now come to an end and his broken health compelled him to seek the more congenial climate of Southern California, and on May 26, 1926, he and his wife left Bloomington never to return. After a long illness he died at a private hospital at Chula Vista in San Diego County, on April 24, 1927. "He lies at rest in San Diego, overlooking the waters he knew so well many years ago."

In Eigenmann, American zoology lost one of its most outstanding investigators. The National Academy of Sciences had honored him as such by electing him a member in 1923, for as one of his ablest pupils has expressed it "he was recognized as one of the foremost ichthyologists of the country and indeed we may place him as one of the four greatest of his time."

Many honors came to Eigenmann in testimony and recognition of his achievements as a scientific worker. He was a fellow of the American Association for the Advancement of Science; Honorary Member of the California Academy of Sciences and the Sociedad Ciencias Naturales, Bogota; Member of the Indiana Academy of Sciences, the Washington Academy of Sciences, the American Microscopical Society, the Society of American Naturalists, the Western Naturalists' Association, the American Zoological Society, Western Zoological Society, American Society of Anatomists, and American Geographical

Society. He was also a member of the Sigma Xi and the Phi Beta Kappa Societies.

Eigenmann's capacity for work was phenomenal, as proven by the many monumental quarto volumes which comprise only a small part of his 228 publications, nearly all devoted to critical, painstaking, detailed, important research.

But research was not the only field to occupy his time and energy. The University of Indiana proclaimed him a great and inspiring teacher. Not knowing this side of his activity, I shall quote a part of what one of his pupils, later assistant, finally colleague and always friend, Professor William J. Moenkhaus, said at the memorial service held at the University:

"As students we were a happy family—apprentices in his workshop in the days when this was in old Owen Hall. Working in the same room with him, each of us was happy in our own problems but none happier than he. He kept us continually informed of his findings and his readings with an informality and enthusiasm that easily convinced us that we were just as enthusiastic and doing something perhaps quite as important. There was no coddling, no prodding, no scolding. All this he left for us to do to ourselves. He was a student of Louis Agassiz, one generation removed, and inherited Agassiz' methods of letting students find things out for themselves and learn to stand on their own feet. He did not believe in the hot-house variety of zoölogist. I have reasons to believe that he liked the subsidized scholar about as well as we like the subsidized athlete. These things bore fruit. A few years ago some thirty of his former pupils from all parts of the country gathered in Cincinnati at a dinner given in his honor. It was most interesting to see that each man acknowledged that the greatest debt he owed him was that he had taught him to be self-reliant and independent in his work. Dr. Eigenmann taught by example.

"He was always direct in his work and went quickly and effectively to the heart of things. Whatever he attacked yielded something. In his work he was careless of the methods to be employed. Fancy instruments and complicated apparatus had no attraction for him. Anything that lay conveniently at hand would suffice. I often marveled at the dexterity of his short, thick fingers dissecting out the miniature teeth or cleaning the skeleton of the little fishes themselves often not larger than a nickel. He was careless of the trimmings of life. Appearances were of no importance to him. His concern was to get

things done. He always knew where he was going and was in a hurry to get there. Quite naturally he was careless of the way in which he dressed up his manuscripts. His editors had a difficult task in untangling them when in his earlier years they were written in longhand. Later he did them on the typewriter, but this did not seem to help the situation very much. Mrs. Eigenmann, herself a trained zoölogist, was invaluable to him not only in her counsel, which he highly prized, but also in the expert way in which she edited his writings and relieved him of these harrowing details. . . .

"He was productive throughout his life. For forty years there flowed from his pen a continuous stream of publications. The so-called wisdom which as a rule possesses one in later middle life did not slow him down. He never lost the enthusiasm and freshness of youth. He remained a boy."

The concluding words of Professor Moenkhaus' eulogy express the sentiments of all who came in contact with him and not least those of his fellow members of the Academy:

"We all admired him for his great scholarship, for his untiring application, and the great amount of work he accomplished under circumstances by no means always the most favorable. Those of us who knew him best loved him for his many first-rate personal qualities, for his splendid tolerance, and, too, for the fortitude with which he in secret bore the sorrows which we knew he had."

BIBLIOGRAPHY

Titles, with exception of last sixteen, listed in the Bibliography of publications by members of the faculty in Vol. 7, No. 51, of Indiana University Studies, pp. 117-127 (December 1921); latter titles kindly supplied by Dr. George S. Myers.

1885

Notes on skeletons of Etheostomatinae. (With David Starr Jordan.) Proc. U. S. Nat. Mus., VIII, pp. 68-72.

1886

A review of the American Eleotridinae. (With Morton W. Fordice.) Proc. Acad. Nat. Sci. Phila. for 1885, VIII, pp. 66-80.

A catalogue of the fishes of Bean Blossom creek, Monroe county, Indiana. (With M. W. Fordice.) Proc. Acad. Nat. Sci. Phila. for 1885, pp. 233-252.

A review of the genera and species of Diodontidae found in American waters. Ann. N. Y. Acad. Sci., III, pp. 297-311.

A review of the Gobiidae of North America. (With D. S. Jordan.) Proc. U. S. Nat. Mus., IX, pp. 477-518.

Folk-lore of a German village. Current, V, No. 124, Chicago, May 1, 1886, pp. 298-299.

1887

A review of the American Gasterosteidae. Proc. Acad. Nat. Sci. Phila. for 1886, pp. 233-252.

A review of the Chaetodontidae of North America. (With Jennie E. Horning.) Ann. N. Y. Acad. Sci., III, pp. 1-18.

Notes on the specific names of certain North American fishes. Proc. Acad. Nat. Sci. Phila. for 1887, pp. 295-296.

A review of the North American species of the genera Lagodon, Archosargus, and Diplodus. (With Elizabeth G. Hughes.) Proc. U. S. Nat. Mus., X, pp. 65-74.

Description of a new species of Ophichthys (*Ophichthys retropinnis*) from Pensacola, Fla. Proc. U. S. Nat. Mus., X, p. 116.

Notes on a collection of fishes sent by Mr. C. C. Leslie from Charleston, S. C. (With D. S. Jordan.) Proc. U. S. Nat. Mus., X, pp. 269-270.

1888

A list of the American species of Gobiidae and Callionymidae, with notes on the specimens contained in the Museum of Comparative Zoölogy, at Cambridge, Mass. (With R. S. Eigenmann.) Proc. Calif. Acad. Sci., 2d ser., I, pp. 51-78.

South American Nematognathi. (With R. S. Eigenmann.) Am. Nat., XXII, pp. 647-649.

Preliminary notes on South American Nematognathi, I. (With R. S. Eigenmann.) Proc. Calif. Acad. Sci., 2d ser., I, pp. 119-172.

Notes on some California fishes, with descriptions of two new species. (With R. S. Eigenmann.) Proc. U. S. Nat. Mus., XI, pp. 463-466.

Cyprinodon californiensis, Girard. (With R. S. Eigenmann.) W. Am. Sci., V, pp. 3-4.

1889

Description of a new species of Cyprinodon. (With R. S. Eigenmann.) Calif. Acad. Sci., 2d ser., I, p. 270.

On the development of California food fishes. Am. Nat. XXIII, pp. 107-110.

Preliminary descriptions of new species and genera of Characinidae. (With R. S. Eigenmann.) W. Am. Sci., VI, pp. 7-8.

Description of new Nematognathoid fishes from Brazil. (With R. S. Eigenmann.) W. Am. Sci., VI, pp. 8-10.

Preliminary notes on South American Nematognathi, II. (With R. S. Eigenmann.) Proc. Calif. Acad. Sci., 2d ser., II, pp. 28-56.

On the phosphorescent spots of *Porichthys margaritatus*. (With R. S. Eigenmann.) W. Am. Sci., VI, pp. 32-34.

Contributions from San Diego Biological Laboratory, I. (With R. S. Eigenmann.) W. Am. Sci., VI, pp. 44-47.

Contributions from the San Diego Biological Laboratory, II. On the genesis of the color-cells of fishes. W. Am. Sci., VI, pp. 61-62.

Notes from the San Diego Biological Laboratory, I. The fishes of Cortez Banks. (With R. S. Eigenmann.) W. Am. Sci., VI, pp. 123-132.

A review of the Sciænidæ of America and Europe. (With D. S. Jordan.) Ann. Rep. Com. Fish and Fisheries for 1886, pp. 343-451, 4 plates.

Notes from the San Diego Biological Laboratory, II. Additions to the fauna of Cortez Banks. Additions to the fauna of San Diego, with notes on some rare species. Fishes of Allen Springs, Lake County, California. The young stages of some Selachians. (With R. S. Eigenmann.) W. Am. Sci., VI, pp. 147-151.

A review of the Erythrininæ. (With R. S. Eigenmann.) Proc. Calif. Acad. Sci., 2d ser., II, pp. 100-116, 1 plate.

A revision of the edentulous genera of Curimatinæ. (With R S. Eigenmann.) Ann. N. Y. Acad. Sci., IV, pp. 1-32.

On the genus Clevelandia. Am. Nat., XXIII, pp. 916-918.

1890

The development of *Micrometrus aggregatus*, one of the viviparous surf-perches. Am. Nat., XXIII, [but Eigenmann's letter is dated Feb. 8, 1890, p. 927], pp. 923-927.

Additions to the fauna of San Diego. (With R. S. Eigenmann.) Proc. Calif. Acad. Sci., 2d ser., III, pp. 1-24.

The evolution of the catfishes. Zoe, I, pp. 10-15.

Description of a fossil species of Sebastodes. Zoe, I, p. 16.

On the egg membranes and micropyle of some osseus fishes. Bull. Mus. Comp. Zoöl., XIX, pp. 129-154, 3 plates.

The barracuda. Zoe, I, pp. 55-56.

The Point Loma blind fish and its relatives. Zoe, I, pp. 65-72, 2 plates.

Charles Harvey Bollman. W. Am. Sci., VII, pp. 5-6.

The coloration of fishes. W. Am. Sci., p. 35.

The food fishes of California fresh waters. Rep. State Board Fish Com. Calif. for 1890, pp. 53-65.

A revision of the South American Nematognathi or Catfishes. (With R. S. Eigenmann.) Occasional Papers Calif. Acad. Sci., I, pp. 508, figures, map.

Descriptions of new species of Sebastodes. (With R. S. Eigenmann.) Proc. Calif. Acad. Sci., 2d ser., III, pp. 36-38.

A review of the genera and species of Serranidæ found in the waters of America and Europe. (With D. S. Jordan.) Bull. U. S. Fish Com., VIII, pp. 329-441, 20 plates.

1891

On the precocious segregation of the sex cells in Micrometrus aggregatus Gibbons. Jour. Morph., V, pp. 480-492, 1 plate.

A catalogue of the fresh-water fishes of South America. (With R. S. Eigenmann.) Proc. U. S. Nat. Mus., XIV, pp. 1-81.

On the genesis of the chromatophores in fishes. Am. Nat., XXV, pp. 112-118, 4 plates.

The spawning season of San Diego fishes. Am. Nat., XXV, pp. 578-579.

Cottus beldingi, sp. nov. (With R. S. Eigenmann.) Am. Nat., XXV, pp. 1132-1133.

A new Diodont. Am. Nat., XXV, p. 1133.

1892

A catalogue of the fishes of the Pacific coast of America north of Cerros Island. (With R. S. Eigenmann.) Ann. N. Y. Acad. Sci., VI, pp. 349-358.

Branchiostoma elongatum Sundevall, at San Diego. Am. Nat., XXVI, p. 70.

On the presence of an operculum in the Aspredinidæ (abstract) Am. Nat., XXVI, p. 70. Proc. Ind. Acad. Sci. for 1891, p. 175.

The Percopsidæ on the Pacific slope. Sci., p. 233.

Recent additions to the fauna of California. (With R. S. Eigenmann.) Abstract. Proc. Ind. Acad. Sci. for 1891, pp. 159-161.

New fishes from Western Canada. (With R. S. Eigenmann.) Am. Nat., XXVI, pp. 961-964.

The continuity of the germ plasm in vertebrates. Proc. Ind. Acad. Sci. for 1891, pp. 169-172.

The eyes of blind fishes. Proc. Ind. Acad. Sci. for 1891, p. 175.

Biological stations. Proc. Ind. Acad. Sci. for 1891, pp. 172-175.

The fishes of San Diego. Proc. U. S. Nat. Mus., XV, pp. 123-178, 9 plates.

1893

Preliminary description of new fishes from the Northwest. (With R. S. Eigenmann.) Am. Nat., XXVII, pp. 151-154.

On the occurrence of the spiny box-fish (genus Chilomycterus) on the coast of California. Proc. U. S. Nat. Mus., XV, p. 485, 1 plate.

Catalogue of the fresh-water fishes of Central America and Southern Mexico. Proc. U. S. Nat. Mus. for 1893, XVI, pp. 53-60.

Preliminary note on the relationship of the species usually united under the generic name Sebastodes. (With C. H. Beeson.) Am. Nat., XXVII, pp. 668-671.

Early stages in the development of Cymatogaster. Proc. Ind. Acad. Sci. for 1892, pp. 58-62.

Explorations in Western Canada. Proc. Ind. Acad. Sci. for 1892, p. 56.

Local variations. Proc. Ind. Acad. Sci. for 1892, p. 81.

1894

A revision of the American Cichlidæ. (With William L. Bray.) Ann. N. Y. Acad. Sci., VII, pp. 607-624.

Notes on some South American fishes. Ann. N. Y. Acad. Sci., VII, pp. 625-637.

On the viviparous fishes of the Pacific coast of North America. Bull. U. S. Fish Com. for 1892, pp. 381-478, 27 plates, pp. 382-400. A review of the Embiotocidæ, in coauthorship with Albert B. Ulrey.

Results of explorations in Western Canada and Northwestern United States. Bull. U. S. Fish Com. for 1894, pp. 101-132, 4 plates.

Biological survey of Indiana: zoölogy. Proc. Ind. Acad. Sci. for 1893, pp. 67-76.

The effect of environment on the mass of local species. Proc. Ind. Acad. Sci. for 1893, pp. 226-229.

A revision of the fishes of the sub-family Sebastinæ of the Pacific coast of America. (With C. H. Beeson.) Proc. U. S. Nat. Mus., XVII, pp. 375-407.

The fishes of Indiana. Report of the Indiana State Biological Survey. (With C. H. Beeson.) Proc. Ind. Acad. Sci. for 1893, pp. 76-108.

The fishes of Indiana. Reprinted from Proc. Ind. Acad. Sci. for 1893. Rep. Ind. State Fish Com. for 1894, pp. 40-64.

Names and locations of Indiana streams. Rep. Ind. State Fish Com. for 1894, pp. 65-79.

Pteropodus dallii, n. sp. Am. Nat., 1894, p. 66.

1895

Leuciscus balteatus (Richardson). A study in variation. Am. Nat., XXIX, pp. 10-25, 5 plates, Jan., 1895; Proc. Ind. Acad. Sci. for 1894, pp. 87-99.

Development of sexual organs in Cymatogaster. Proc. Ind. Acad. Sci. for 1894, p. 138.

A new biological station and its aim. Proc. Ind. Acad. Sci. for 1894, pp. 34-35.

1896

First report of the Indiana University Biological Station. Pt. I, Turkey lake as a unit of environment, pp. 209-239. Pt. II, The inhabitants of Turkey lake, pp. 239-264. Pt. III, Variation, pp. 265-296. Proc. Ind. Acad. Sci. for 1895, plates.

The bearing of the origin and differentiation of the sex cells in Cymatogaster on the idea of the continuity of the germ plasm. Am. Nat., XXX, pp. 265-271.

Sex differentiation in the viviparous teleost Cymatogaster. Archiv f. Entwickelungsmechanik, IV, pp. 125-179, 6 plates. Abstract in Trans. Am. Micr. Soc., XVII, pp. 172-173.

1897

Steindachneria. Am. Nat., XXXI, pp. 158-159.

1898

The Amblyopsidæ, the blind fish of America. Rep. Brit. Asso. for 1897, pp. 685-686.

The origin of cave faunas (abstract). Ind. Acad. Sci. for 1897, pp. 229-230.

The Amblyopsidæ and eyes of blind fishes (abstract). Proc. Ind. Acad. Sci. for 1897, pp. 230-231.

A new blind fish. Proc. Ind. Acad. Sci. for 1897, p. 231.

Biological stations. Ind. Woman.

1899

The Indiana University Biological Station. Sci., N.S., X, pp. 925-929 (Dec. 22, 1899); Inland Educ. for 1900, pp. 61-65, figures.

Plans for the new buildings of the Biological Station. Proc. Ind. Acad. Sci. for 1898, pp. 55-58.

A case of convergence. Sci., N.S., IX, No. 217, 280-282 (Feb., 1899); Proc. Ind. Acad. Sci. for 1898, pp. 247-257.

Viviparous fishes. Overland Mo., 1899, pp. 217-224.

Explorations in the caves of Missouri and Kentucky. Proc. Ind. Acad. Sci. for 1898, pp. 58-61.

The blind fishes of North America. Pop. Sci. Mo., LVI, pp. 473-486.

The eyes of the blind vertebrates of North America, I. The eyes of the Amblyopsidæ. Archiv f. Entwickelungsmechanik, VIII, pp. 545-617, 5 plates.

Notes on the blind fishes. Sci., N.S., IX, p. 370.

Preliminary notes upon the arrangement of rods and cones in the retina of fishes. (With George Hansell.) Proc. Ind. Acad. Sci. for 1898, p. 239.

Degeneration in the eyes of the Amblyopsidæ, its plan, process and causes. Proc. Ind. Acad. Sci. for 1898, pp. 239-241.

The ear and the hearing of the blind fishes. (With Albert C. Yoder.) Proc. Ind. Acad. Sci. for 1898, pp. 242-247, 2 plates.

Chologaster agassizii and its eyes. Proc. Ind. Acad. Sci. for 1898, p. 251.

The eye of Typhlomolge from the artesian wells of San Marcos, Tex. (abstract). Proc. Ind. Acad. Sci. for 1898, p. 251.

The eyes of *Typhlotriton spelaeus* (abstract). (With W. A. Denny.) Proc. Ind. Acad. Sci. for 1898, pp. 252-253.

The blind rat of Mammoth cave. (With James Rollin Slonaker.) Proc. Ind. Acad. Sci. for 1898, pp. 253-257, figures.

Cave animals, their character, origin, and their evidence for or against the transmission of acquired characters. Sci., N.S., X, p. 883.

1900

The blind fishes. Biol. Lectures Marine Biol. Lab. of Woods Hole for 1899, pp. 113-126.

The mosaic of single and twin cones in the retina of fishes. (With George Daniel Shafer.) Am. Nat., XXXIV, pp. 109-118, 1 plate.

Degeneration in the eyes of the cold-blooded vertebrates of the North American caves. Sci., N.S., XI, pp. 492-503, figures.

The structure of blind fishes. Pop. Sci. Mo., LVII, pp. 48-58.

The eyes of blind vertebrates of North America, II. The eyes of *Typhlomolge rathbuni* Stejneger. Trans. Am. Micr. Soc., XXI, pp. 49-60, 2 plates.

Causes of degeneration in blind fishes. Pop. Sci. Mo., LVII, pp. 397-407.

Some cases of saltatory variation. (With Ulysses Cox.) Sci., N.S., XII, p. 300.

A contribution to the fauna of the caves of Texas. Sci., N.S., XII, p. 301.

Sobre alguns peixes de S. Paulo, Brazil. (With Allen A. Norris.) Revista do Museu Paulista, IV, pp. 349-362.

Degeneration in the eyes of the cold-blooded vertebrates of the North American caves. Proc. Ind. Acad. Sci. for 1899, pp. 31-46, illustrations.

Convergent evolution as illustrated by the blind lizard Rhineura. Sci., N. S., XII, p. 302.

The development of the eyes in the blind-fish Amblyopsis. Proc. Am. Asso. Adv. Sci., 1900, p. 230; Sci., N. S., XII, p. 302.

The eyes of the cave salamander Typhlotriton. Sci., N. S., XII, p. 302.

The development of the Conger eel. Sci., N. S., XII, pp. 401-402.

The eyes of the blind vertebrates of North America, III. The structure and ontogenic degeneration of the eyes of the Missouri cave salamander. (With Winfield Augustus Denny.) Biol. Bull., II. 33-40, 1 plate.

Description of a new cave salamander, *Spelerpes stejnegeri,* from the caves of southwestern Missouri. Trans. Am. Micr. Soc., XXII, pp. 189-192, 2 plates (1900); abstract, Proc. Ind. Acad. Sci. for 1900, pp. 167 (1901).

1901

Some cases of saltatory variation. (With U. O. Cox.) Am. Nat., XXXV, pp. 33-38.

Bergiaria. (With Allen A. Norris.) Com. Mus. Nac. Buenos Aires, I, p. 272.

Unilateral coloration with a bilateral effect. (With Clarence Kennedy.) Sci., XIII, pp. 828-830.

Description of a new oceanic fish (*Psenes edwardsii,* n. sp.) found off southern New England. Bull. U. S. Fish Com., XXI, p. 35 (1901); abstract, Proc. Ind. Acad. Sci. for 1900, p. 166.

The egg and development of the Conger eel (*Leptocephalus conger*). Bull. U. S. Fish Com., XXI, pp. 37-44, illustrations (1901); abstract, Proc. Ind. Acad. Sci. for 1900, pp. 165-166.

The Leptocephalus of the American eel and other American Leptocephali. (With Clarence Hamilton Kennedy.) Bull. U. S. Fish Com., XXI, pp. 81-92, illustrations (1901); abstract, Sci., N. S. XIV, p. 631 (Oct. 25, 1901).

The mounting of the remains of *Megalonyx jeffersoni* from Henderson, Ky. Proc. Ind. Acad. Sci. for 1900, p. 166.

1902

The solution of the eel question. Trans. Am. Micr. Soc., XXIII, pp. 5-18, 4 plates; Sci., N. S., XV, p. 636.

The physical basis of heredity. Pop. Sci. Mo., LXI, pp. 32-44, illustrations.

The blind fish of Cuba. Sci., N. S., XVI, p. 347; Carnegie Institution Year Book, Washington, D. C., 1904, No. 2, p. xlii.

Investigations into the history of the young Squeteague (*Cynoscion regalis*). Bull. U. S. Fish Com., XXI, pp. 45-51, illustrations (1901); abstract, Proc. Ind. Acad. Sci. for 1900, p. 166.

The Carnegie Institution. Sci., N. S., XVI, pp. 792-793.

The eyes of the blind vertebrates of North America, IV. The eyes of *Rhineura floridana*. Proc. Wash. Acad. Sci., IV, pp. 533-548, 3 plates (Sept., 1902); abstracts, Proc. Ind. Acad. Sci. for 1901, p. 107 (1902); Sci., N. S., XIV, p. 631 (Oct. 25, 1901).

The history of the eye of Amblyopsis (abstracts). Proc. Ind. Acad. Sci. for 1901, pp. 101-105 (1902); Sci., N. S., XIV, p. 631 (Oct. 25, 1901); Sci., N. S., XV, pp. 523-524.

Zoölogical miscellany. Proc. Ind. Acad. Sci. for 1901, pp. 107-113.

1903

The solution of the eel problem. World Today, IV, pp. 478-482.

In search of blind fishes in Cuba. World Today, V, pp. 1131-1136, illustrations.

Auf der Suche nach blinden Fischen in Cuba. Die Umschau, VII, pp. 365-367.

Variation notes. (With C. H. Kennedy.) Biol. Bull., IV, pp. 227-230.

The fresh-water fishes of western Cuba. Bull. U. S. Fish Com. for 1902, pp. 211-236, 4 plates.

The water supply of Havana, Cuba. Sci., N. S., XVIII, pp. 281-282 (Aug. 28, 1903); Proc. Ind. Acad. Sci. for 1902, pp. 65-67.

On a collection of fishes from Paraguay with a synopsis of the American genera of cichlids. (With C. H. Kennedy.) Proc. Acad. Sci. Phila. for 1903, pp. 497-537.

New genera of South American fresh-water fishes, and new names for some old genera. Smithsonian Misc. Coll., XLV, pp. 144-148.

1904

The eyes of the blind vertebrates of North America, V. The history of the eye of Amblyopsis from the beginning of its development to its disintegration in old age. E. L. Mark anniversary volume, pp. 167-204, plates xii-xv; abstract, Proc. Ind. Acad. Sci. for 1901, pp. 101-105.

On a Leptocephalus of the Conger eel. Sci., N. S., XIX, pp. 629-630, figures.

1905

Divergence and convergence in fishes. Biol. Bull. Woods Hole, VIII, pp. 59-66, 4 figures.

The mailed cat-fishes of South America (Loricariidae). Sci., N. S., XXI, pp. 792-795.

The Gymnotidae. (Joint author with David Perkins Ward.) Proc. Wash. Acad. Sci., VII, pp. 159-188, plates VII-XI.

The fishes of Panama. Sci., N. S., XXII, pp. 18-20.

1906

Fresh-water fishes of South and Middle America. Pop. Sci. Mo., June, 1906, pp. 515-530.

The Smithsonian Institution and research. Sci., N. S., XXIV, pp. 553-556.

1907

An account of Amazon river fishes collected by J. B. Steere, with a note on *Pimelodus clarias*. (With Barton A. Bean.) Proc. U. S. Nat. Mus., XXXI, pp. 659-668, 5 figures.

On a collection of fishes from Buenos Aires. Proc. Wash. Acad. Sci., VIII, pp. 449-458, plates XXI-XXIII.

The Poeciliid fishes of Rio Grande do Sul and the La Plata Basin. Proc. U. S. Nat. Mus., XXXII, pp. 425-433, 11 figures.

An annotated list of characin fishes in the United States National Museum and the Museum of Indiana University, with descriptions of new species. (With Fletcher Ogle.) Proc. U. S. Nat. Mus., XXXIII, pp. 1-36.

Fowler's "Heterognathous fishes," with a note on the Stethaprioninæ (Review). Am. Nat., XLI, pp. 767-772.

On further collections of fishes from Paraguay. (With Waldo L. McAtee and David Perkins Ward.) Ann. Carnegie Mus., IV, pp. 110-157, plates XXXI-XLV.

1908

Preliminary descriptions of new genera and species of Tetragonopterid characins. Bull. Mus. Comp. Zoöl., LII, pp. 93-106.

1909

Adaptation. (In 'Fifty years of Darwinism', pp. 182-208, plates III and IV. Henry Holt and Co.)

Cave vertebrates of North America: a study in degenerative evolution. Publ. of the Carnegie Institution, No. 104, pp. 341, frontispiece, plates A and 1-29.

The fresh-water fishes of Patagonia and an examination of the Archiplata-Archhelenis theory. Rep. Princeton Univ. Exped. Patagonia, 1896 to 1899, Zoöl., III, pp. 225-374, plates XXX-XXXVI, 2 maps.

Reports on the expedition to British Guiana of the Indiana University and the Carnegie Museum, 1908, Rep. No. 1. Some new genera and species of fishes from British Guiana. Ann. Carnegie Mus., VI, pp. 4-54.

1910

Catalogue of the fresh-water fishes of tropical and south temperate America. Rep. Princeton Univ. Exped. Patagonia, 1896 to 1899, Zoölogy, III, pp. 375-511.

1911

Description of two new Tetragonopterid fishes in the British Museum. Ann. and Mag. Nat. Hist., Ser. 8, VII, pp. 215-217.

New characins in the collection of the Carnegie Museum. Ann. Carnegie Mus., VIII, pp. 164-181, plates IV-IX.

Description of a new species of Pygidium. Ann. Carnegie Mus., p. 214, plate XXXII.

A list of localities at which Mr. Haseman collected. Ann. Carnegie Mus., VII, pp. 299-314.

1912

The fresh-water fishes of British Guiana, including a study of the ecological groupings of species, and the relation of the fauna of the plateau to that of the lowlands. Mem. Carnegie Mus., V, pp. xx, 578, plates A and I-CIII.

The Cuban blind fishes. Proc. 7th Internat. Zoöl. Congr. Boston, 1907, pp. 697-698.

The origin of the fish-fauna of the fresh waters of South America. Proc. 7th Internat. Zoöl. Congr. Boston, 1907, pp. 958-959.

Some results from an ichthyological reconnaissance of Colombia, South America, I. Ind. Univ. Studies, No. 16, pp. 27.

1913

A naturalist in British Guiana. Outdoor World and Recreation, XLVIII, No. 5, pp. 250-251.

Some results from an ichthyological reconnaissance of Colombia, South America, II. Ind. Univ. Studies, No. 18, pp. 32.

On two new species of fishes collected by Miss Lola Vance in Peru. Ann. Carnegie Mus., VIII, pp. 421-422.

The fishes of South America. Bull. Pan-American Union, XXXVII, No. 6, pp. 781-800, 18 figures.

1914

Los peces de Sud America. Boletin de la Union Panamericana, XXXVIII, No. 1, pp. 1-21.

New fishes from western Colombia, Ecuador, and Peru. (With Arthur Henn and Charles Wilson.) Ind. Univ. Studies, No. 19, pp. 15.

Some results from studies of South American fishes. Ind. Univ. Studies, No. 20, pp. 18-48.

On new species of fishes from the Rio Meta basin of eastern Colombia and on albino or blind fishes from near Bogota. Ind. Univ. Studies, No. 23, pp. 229-230.

On new species of fishes from Colombia, Ecuador, and Brazil. (With Arthur Henn.) Ind. Univ. Studies, No. 24, pp. 231-234.

The Gymnotidae of trans-andean Colombia and Ecuador. (With Homer G. Fisher.) Ind. Univ. Studies, No. 25, pp. 235-237.

1915

The Cheirodontinae, a sub-family of minute characid fishes of South America. Mem. Carnegie Mus., VII, pp. 1-99.

The Serrasalminae and Mylinae. Ann. Carnegie Mus., IX, pp. 226-272.

1916

Description of a new *Sphagebranchus* from the Bahamas. Ann. Carnegie Mus., X, pp. 55-56.

On Apareiodon, a new genus of characid fishes. Ann. Carnegie Mus., X, pp. 71-76.

New and rare fishes from South American rivers. Ann. Carnegie Mus., X, pp. 77-86.

Description of three new species of characid fishes. (With Arthur W. Henn.) Ann. Carnegie Mus., X, pp. 87-90.

On the species of Salminus. Ann. Carnegie Mus., X, pp. 91-92.

1917

Some species of Farlowella. (With Lola Vance.) Ann. Carnegie Mus., XI, pp. 297-303.

Pimelodella and Typhlobagrus. Mem. Carnegie Mus., VII, pp. 229-258.

The American Characidae. Mem. Mus. Comp. Zoöl., Harvard Coll. XLIII, Pt. 1, pp. 1-102, plates 1-8, 12, 14, 15, 16, 95, 98, 100, 101.

On some species of *Rhamdia,* a genus of South American Siluridae, in the Carnegie Museum. (With Homer G. Fisher.) Ann. Carnegie Mus., XI, pp. 394-397.

New and rare species of South American Siluridae in the Carnegie Museum. Ann. Carnegie Mus., XI, pp. 394-404.

Eighteen new species of fishes from northwestern South America. Proc. Am. Phil. Soc., LVI, pp. 674-689.

Descriptions of sixteen new species of Pygidiidae. Proc. Am. Phil. Soc., LVI, pp. 690-703.

The homes of blind fishes. The Geographical Rev., IV, No. 3, pp. 171-182.

1918

The American Characidae. Mem. Mus. Comp. Zoöl., Harvard Col., XLIII, Pt. 2, 103-208, plates 9, 10, 11, 13, 17 to 29, 33, 78 to 80, 93.

The Irwin expedition. Sci., N. S., XLVIII, pp. 108-109.

The aquatic vertebrates. (In Ward and Whipple's "Fresh-water biology", pp. 1021-1066.)

The Pygidiidae, a family of South American cat-fishes. Mem. Carnegie Mus., VII, pp. 259-373, plates XXVI to LVI.

The Pygidiidae. Proc. Ind. Acad. Sci. for 1917, pp. 59-66.

1919

The Irwin expedition. Sci., N. S., L, pp. 100-102.

Trogloglanis Pattersoni, a new blind fish from San Antonio, Tex. Proc. Am. Phil. Soc., LVIII, pp. 397-400.

Steindachneridion. (With Rosa Smith Eigenmann.) Sci., N. S., L, pp. 525-526.

1920

The Irwin expedition to Peru, Bolivia, and Chile. Ind. Univ. Alum. Quart., VII, No. 1, pp. 1-16.

Limits of the genera Vandellia and Urinophilus. Sci., N. S., LI, p. 441.

The fishes of Lake Valencia, Caracas, and the Rio Tuy at El Concejo, Venezuela. Ind. Univ. Studies, VII, No. 44, pp. 13, 3 plates, 3 text-figures.

The fish fauna of the Cordillera of Bogota. Jour. Wash. Acad. Sci., X, pp. 461-468.

South America west of the Maracaibo, Orinoco, Amazon, and Titicaca basins, and the horizontal distribution of its fresh-water fishes. Ind. Univ. Studies, VII, No. 45, pp. 24.

The fishes of the rivers draining the western slope of the Cordillera Occidental of Colombia, Rios Atrato, San Juan, Dagua, and Patia. Ind. Univ. Studies, VII, No. 46, pp. 19.

1921

The freshwater fishes of Panama, east of Longitude 80° W. Ind. Uni. Studies, No. 47, A, pp. 3-19.

The Magdalena Basin and the horizontal and vertical distribution of its fishes. Ind. Univ. Studies, No. 47, B, pp. 20-34.

The American Characidae. Part 3. Mem. Mus. Comp. Zoöl., Harvard Col., XLIII, Pt. 3, pp. 209-310, 28 plates.

The origin and distribution of the genera of the fishes of South America west of the Maracaibo, Orinoco and Amazon Basins. Proc. Am. Phil. Soc., LX, No. 1, pp. 1-6.

The nature and origin of the fishes of the Pacific slope of Ecuador, Peru and Chile. Proc. Am. Phil. Soc., LX, No. 4, pp. 503-523, pl. 8-10.

A leaf-mimicking fish. (With William Ray Allen.) Biol. Bull., XLI, No. 5, pp. 301-305.

1922

Yellow fever and fishes. Proc. Am. Phil. Soc., LXI, No. 3, pp. 204-211.

On a new genus and two new species of Pygidiidae, a family of South American Nematognaths. Bijdragen tot de Dierkunde, Afd. 22, pp. 113-114, pl. 3-4.

The Fishes of Western South America, Part 1. The Fresh-water Fishes of Northwestern South America, including Colombia, Panama and the

Pacific Slopes of Ecuador and Peru, together with an Appendix upon the Fishes of the Rio Meta in Colombia. (Plates 1-38.) Mem. Carnegie Mus., vol. IX, No. 1, pp. 1-346. [On cover: Published by the Board of Trustees of the Carnegie Institute, October, 1922.]

1923

The fishes of the Pacific slope of South America and the bearing of their distribution on the history of the development of the topography of Peru, Ecuador and Western Colombia. Am. Nat., LVII, pp. 193-210.

The Andes in Northern Peru. Sci. N. S., LXIII, No. 1513, p. 532.

1924

Yellow fever and fishes in Colombia. Proc. Am. Phil. Soc., LXIII, No. 3, pp. 236-238, pl. 1.

1925

A review of the Doradidae, a family of South American Nematognathi, or Catfishes. Trans. Am. Phil. Soc., XXII, Pt. 5, pp. 280-365, 27 pl.

1927

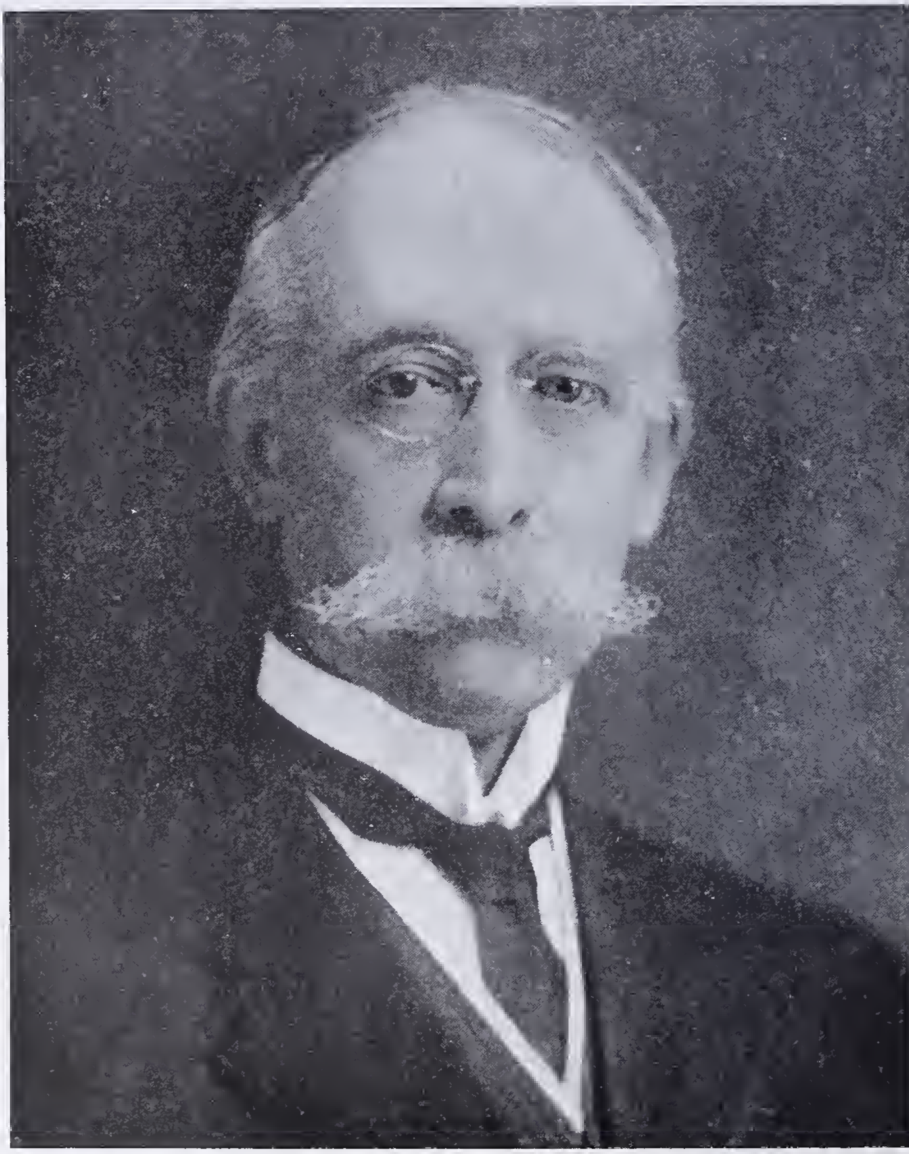
The freshwater fishes of Chile. Mem. Nat. Acad. Sci., XXI, 2nd mem., iii+63 pp., 16 pl.

The American Characidae. Part 4. Mem. Mus. Comp. Zoöl., Harvard Col., XLIII, Pt. 4, pp. 311-428, 24 plates.

A new genus of Brazilian Characin fishes allied to Bivibranchia. (With George S. Myers). Proc. Nat. Acad. Sci., XIII, No. 8, pp. 565-566.

1929

The American Characidae. Part 5. (With George S. Myers.) Mem. Mus. Comp. Zoöl., Harvard Col., XLIII, Pt. 5, pp. 429-558, 11 plates.



Arthur Gordon Webster

NATIONAL ACADEMY OF SCIENCES
OF THE UNITED STATES OF AMERICA
BIOGRAPHICAL MEMOIRS
VOLUME XVIII—FOURTEENTH MEMOIR

BIOGRAPHICAL MEMOIR

OF

ARTHUR GORDON WEBSTER

1863–1923

BY

JOSEPH S. AMES

PRESENTED TO THE ACADEMY AT THE ANNUAL MEETING, 1937

ARTHUR GORDON WEBSTER

1863–1923

BY JOSEPH S. AMES

Arthur Gordon Webster was born at Brookline, Mass., on November 28, 1863, and died at Worcester, Mass., on May 15, 1923. The outstanding dates in his scientific life are not numerous, because he was connected for so many years with one institution, Clark University of Worcester. He received his bachelor's degree from Harvard in 1885 and was awarded in the following year a Parker Fellowship, which carried him abroad. He spent part of this time at the University of Berlin, where he received the degree of doctor of philosophy, in 1890. He returned immediately to Clark University as docent in physics, which position he held for two years. Following this, he was assistant professor until 1900, when he was elected professor of physics, upon the transfer of Michelson to Chicago. This position he held until his death. He was awarded the Elihu Thompson prize in physics in 1895, the award being given for his experimental researches on the Period of Electrical Oscillations. In 1903 he was elected president of the American Physical Society, having been a member of its Council from the foundation of the Society. In the same year he was elected a member of the National Academy of Sciences.

He was the son of William Edward and Mary Shannon Davis Webster, and on October 8, 1889, he married Elizabeth Munroe Townsend of Syracuse, N. Y. Professor Webster was extremely interested in the meetings of the National Academy, but especially, I think, in those of the American Physical Society, a group which he was influential in forming. All those who were present at the meetings of the latter Society during its first years will remember with great pleasure the personal interest shown by Professor Webster, not alone in the papers, but in the speakers. In his early days at Harvard, and later at the

University of Berlin, he developed and exhibited those traits which endeared him to a whole generation of students of physics. His outstanding characteristics were, undoubtedly, his versatility, his personality, and his competence in his chosen field of work.

His versatility was as great as that of any man of his age. He was a skilled musician, and an artist, gifted in the use of brush and pencil. He was also a natural-born linguist, who found all languages easy, including even modern Greek. I remember meeting him in the fall of 1886, as we were standing outside the door leading to the study of the great Helmholtz. He was carrying on an animated conversation in German with some students of that nationality who were standing with us, and I shall never forget his astonishment when I addressed him as a fellow American. He asked me how I knew he was an American and I told him that while his German was perfect, he had forgotten to dress the part, and I advised him to look at the heels of his shoes.

Webster's personality was most striking and, although he was prompted to speak in regard to almost every paper which was read before the Physical Society, his comments were always friendly, inspiring, and sympathetic. No one ever had the idea that Webster was trying to display his own knowledge. It was difficult at times for the presiding officer to induce him to confine his remarks to the subject of the paper, but what he had to say was always of great interest and often of importance. He was vividly alive to and most interested in every new development in physics. Mathematics to him was always comparatively easy and of the greatest interest. The subject of mathematics appealed to him largely as a means by which he could understand more clearly and explain more completely the physical ideas which were continually rising in his mind. His main purpose in learning the new branches of mathematics as they were successively developed was to help him formulate his own physical problems in such a way that they could be solved. He was a skilled experimentalist, but the mathematical side of the subject

always appealed to him strongly. No one of his time possessed anything like the power which he had of formulating a physical problem in mathematical language. He was taught at Harvard and Berlin and Paris to believe that the mathematical mode of approach was essential in all fields of physics, and his ability was mostly shown in the prosecution of this line of thought. His work in physics was concerned in the main with what one would now-a-days call the classical problems. He was more interested in the problems dealing with sound and sounding instruments than almost any other subject, and his researches, both theoretical and experimental, were of marked importance.

Webster's contributions to physics and mathematics are well illustrated by the bibliography of his publications appended to this sketch. His books were all notable and were extremely successful. He was a born teacher and expounder and was able to enliven all subjects in physics with the magic touch of humor and wit. No subject was ever dull as it was considered by him. It would not be fair to say his treatises were profound, but they did represent perfectly the knowledge of his time and gave evidence of extremely careful preparation by a man who was master of his subject and fully familiar with all the writings on the subject under discussion. His original contributions were varied and interesting. He never approached an experimental problem without marked improvement both in apparatus and method. His researches may truly be called distinguished, and his contributions to knowledge have stood the test of time and later observations. As has been said before, he was able to formulate problems in such a way as would make them amenable to mathematical discussion, and he was, therefore, led to conduct his experiments along lines which would lead to not alone an increased knowledge of facts, but also have a bearing upon theory and future development of the science. He was as much interested in what one may properly call the engineering side of his subject as in the purely physical one, and his ability was so great that there was no practical field in which he could not venture with great profit to all concerned.

When he was a boy, even before he went to college, his father had fitted up for him a quite good laboratory at home, and both here and in the physics laboratory at Harvard he soon became skilled in experimentation. When he studied at Harvard he became attracted by the mathematical sciences and learned in an extremely short time a fundamental basis for all his future work. He took advantage to the full of the opportunities offered there for optional studies and courses and few men have ever gone to Europe so well prepared to continue their studies. His versatility was so great and his interest in all that made up life was so intense that he did not find it easy to prepare a dissertation for his doctor's degree. He made a profound impression upon all his associates and fellow students and he was in all respects outstanding in a large group of men. As has been noted before, he was always attracted to what one may call engineering problems. His knowledge of dynamics and of electricity was so fundamental, almost intuitive, that his advice in all the practical applications of these subjects was eagerly sought. His suggestions were inspiring and useful.

Webster possessed a very true appreciation of his own great ability, and this appreciation was entirely free from any feeling or any thought of jealousy. He had, as has been said, a really profound knowledge of both physics and mathematics and was extremely helpful in making suggestions for advances in these fields. His comments on the work of others were always constructive and encouraging. It has sometimes been thought that his understanding of physics was not such as would lend itself to an appreciation of the more modern problems. He lived at a time when the new physics, dealing with our knowledge of atomic structure and our theoretical knowledge of wave mechanics, were practically unknown. His concepts of fundamental work were largely mathematical and no one can tell today how his ability would have developed.

Shortly after Webster's death in May, 1923, a university meeting in honor of his memory was called at Clark University. At this meeting President Atwood presided and there were

addresses given by students and friends who had known him well. A full account of the meeting, together with addresses and letters, was published in Volume 7 of the Publications of the Clark University Library, March, 1924. Appended to that, as there is also to this sketch, is an extremely accurate bibliography prepared by the assistant librarian of Clark University. This list of papers and books is the best illustration one could wish of Webster's interest in physical matters and of his great ability as a physicist.

BIBLIOGRAPHY

Compiled by

Edith M. Baker, Assistant Librarian, Clark University

On a new method for determining the mechanical equivalent of heat. Amer. Acad. Arts and Sci. Proc., May 1885. Vol. 20, pp. 490-493.
Reviewed by G. Richard in La lumière électrique, 1885. Vol. 17, pp. 545-547.

Versuche über eine Methode zur Bestimmung des Verhältnisses der elektromagnetischen zur elektrostatischen Einheit der Elektricität. Thesis, Ph.D. Friedrich Wilhelms Univ. Berlin, G. Schade, 1890. 32 pp.

"W=Mg." Nature, Nov. 2, 1891. Vol. 45, p. 29.

Some experiments on a new method for the determination of "v." British Assoc. Adv. Sci. Report, 1891. 61st meeting, pp. 580-581.

A national physical laboratory. Ped. Sem., Je. 1892. Vol. 2, pp. 90-101.

Unipolar induction and current without difference of potential. Electrical World, Apr. 14-21, 1894. Vol. 23, pp. 491-492; 523-524.

Fourier's series and harmonic functions. N. Y. Math. Soc., Bull. Jl. 1894. Vol. 3, pp. 245-248.

The theory of electricity and magnetism, being lectures on mathematical physics. London, Macmillan, 1897. 576 pp.

On a means of producing a constant angular velocity. Amer. Jour. Sci., May 1897. Ser. 4, Vol. 3, pp. 379-382.

A rapid break for large currents. Amer. Jour. Sci., May 1897. Ser. 4, Vol. 3, pp. 383-386.
Reviewed in La lumière électrique, 1897. Vol. 13, pp. 472-474.

A new instrument for measuring the intensity of sound. British Assoc. Adv. Sci. Report 1897. 67th meeting, p. 584.
Also in Amer. Assoc. Adv. Sci. Proc., 1898. 47th meeting, p. 136.

The mathematics used in connection with physics. Nature, Feb. 3, 1898. Vol. 57, p. 317.

An experimental determination of the period of electrical oscillations. Physical Rev., May-Je., 1898. Vol. 6, pp. 297-314.

Note on Stokes's theorem in curvilinear co-ordinates. Amer. Acad. Arts and Sci. Proc., Je. 1898. Vol. 33, pp. 381-385.
Also in Amer. Math. Sci. Bull., Je. 1898. Ser. 2, Vol. 4, pp. 438-441.

Measurements of precision. Science, Nov. 25, 1898. N.S. Vol. 8, pp. 749-751.

Report on the state of the mathematical theory of electricity and magnetism. Science, Dec. 9, 1898. N.S. Vol. 8, pp. 803-810.
Also in Amer. Assoc. Adv. Sci. Proc., 1898. 47th meeting, pp. 103-112.

A new chronograph and a means of rating tuning-forks. Amer. Assoc. Adv. Sci. Proc., 1898. 47th meeting, p. 136.

A geometrical method for investigating diffraction by a circular aperture. Amer. Assoc. Adv. Sci. Proc., 1898. 47th meeting, p. 136.

The geometrical properties of linear vector functions and their application to strain and stress. 1899. 7 pp. (Typewritten. Clark Univ. library.)

On the deduction of the equations of electromagnetic waves. Amer. Physical Soc. Bull., 1900. Vol. 1, pp. 22-23. (Abstract)

On a new apparatus to show the motion of the top. Amer. Physical Soc. Bull., 1900. Vol. 1, p. 23. (Abstract)

The larynx as an instrument of music. Science, May 24, 1901. N.S. Vol. 13, p. 827.

A portable apparatus for the measurement of sound. Science, Jan. 30, 1903. N.S. Vol. 17, p. 175.

Mechanical efficiency of musical instruments as sound producers. Science, Jan. 30, 1903. N.S. Vol. 17, pp. 175-176.

Also in Physical Rev., Apr. 1903. Vol. 16, pp. 248-249.

The dynamics of particles and of rigid, elastic, and fluid bodies; being lectures on mathematical physics. Leipzig, Teubner, 1904. 588 pp. (Samml. der math. Wissenschaften, Bd. 11.)

On the mechanical efficiency of the production of sound. Boltzmann-Festschrift, Leipzig, Barth, 1904. Pp. 866-875.

Some practical aspects of the relations between physics and mathematics. Physical Rev., Apr. 1904. Vol. 18, pp. 297-318.

The metric system. Science, Je. 3, 1904. N.S. Vol. 19, p. 860.

The so-called international electrical units by F. A. Wolff. Discussion by A. G. Webster. Inst. Electrical Engineers Jour., 1904. Vol. 34, pp. 212-213; 222-223.

Lorentz's theory of electricity. Inter. Elect. Cong. Trans., St. Louis, 1904. Albany, 1905. Vol. 1, pp. 302-316.

Application of a definite integral involving Bessel's functions to the self-inductance of solenoids. Amer. Math. Soc., Bull., Oct. 1907. Ser. 2, Vol. 14, pp. 1-6.

Lord Kelvin. Science, Jan. 3, 1908. N.S. Vol. 27, pp. 1-8.

America's intellectual product. Pop. Sci. Mo., Mar. 1908. Vol. 72, pp. 193-210.

Phi Beta Kappa Oration. Hobart College Bull., Proc. of Commencement. Je. 1908. Vol. 6, No. 4, pp. 7-31.

The gyroscope and how we may make it useful. Amer. Rev. of Revs., Aug. 1908. Vol. 38, pp. 205-209.

The definition of a perfect gas. Abstract of a paper presented at New York meeting of the Physical Society, October 24, 1908. Physical Rev., Jan. 1909. Vol. 28, p. 65.

The distribution of sound from the megaphone. Physical Rev., Jan. 1909. Vol. 28, p. 65.

The reflection of sound from the ground. Physical Rev., Jan. 1909. Vol. 28, p. 65.

On the definition of an ideal gas. (With M. A. Rosanoff). Physical Rev., Sept. 1909. Vol. 29, pp. 304-309.

Nature study. Science, Oct. 15, 1909. N.S. Vol. 30, p. 525.

Science and inaugurations. Nation, Oct. 21, 1909. Vol. 89, pp. 376-377.

Scientific faith and works. Pop. Sci. Mo., Feb. 1910. Vol. 76, pp. 105-123.

National Academy of Sciences. Nation, Apr. 28, 1910. Vol. 90, pp. 440-441.

The past and present status of the ether. Pop. Sci. Mo., Aug. 1910. Vol. 77, pp. 105-113.

A complete apparatus for the measurement of sound. British Assoc. Adv. Sci. Report 1910. 80th meeting, p. 534.

National Academy of Sciences. Nation, May 4, 1911. Vol. 92, pp. 442-443.

Sur un nouveau problème mixte de l'équation des télégraphistes. Paris, C. R. Acad. Sci., Aug. 28, 1911. Vol. 153, pp. 500-503.

Moisture and out-of-doors. Science, Sept. 8, 1911. N.S. Vol. 34, pp. 312-314.

Electrons. Science, Sept. 8, 1911. N.S. Vol. 34, pp. 314-315.

Science of government. Science, Sept. 8, 1911. N.S. Vol. 34, p. 315.

Due—. Science, Sept. 8, 1911. N.S. Vol. 34, pp. 315-316.

Business men and scholars. Nation, Sept. 14, 1911. Vol. 93, pp. 238-239.

Scientific management and academic efficiency. Nation, Nov. 2, 1911. Vol. 93, pp. 416-417.

The National Academy of Sciences. Nation, Nov. 30, 1911. Vol. 93, pp. 526-528.

The wave potential of a circular line of sources. Amer. Acad. Arts and Sci. Proc., Dec. 1911. Vol. 47, pp. 315-318.

The dynamics of particles and of rigid, elastic, and fluid bodies; being lectures on mathematical physics. 2nd ed. Leipzig, Teubner, 1912. 488 pp. (Samml. der math. Wissenschaften, Bd. 11.)

On a new mixed problem of the partial differential equation of telegraphy. Amer. Math. Soc., Bull., Feb. 1912. Ser. 2, Vol. 18, pp. 244-253.

National Academy of Sciences. Nation, Apr. 25, 1912. Vol. 94, pp. 420-421.

National Academy of Sciences. Nation, Nov. 21, 1912. Vol. 95, pp. 490-491.

Semi-centennial of the National Academy of Sciences. Nation, May 1, 1913. Vol. 96, pp. 447-449.

National Academy of Sciences. Nation, Nov. 27, 1913. Vol. 97, pp. 517-518.

Henri Poincaré as a mathematical physicist. Science, Dec. 26, 1913. N.S. Vol. 38, pp. 901-908.

The methods of the physical sciences. To what are they applicable? Science, Jan. 9, 1914. N.S. Vol. 39, pp. 42-51.

The physical laboratory and its contributions to civilization. Pop. Sci. Mo., Feb. 1914. Vol. 84, pp. 105-117.

Benjamin Osgood Peirce. Science, Feb. 20, 1914. N.S. Vol. 39, pp. 274-277.

Benjamin Osgood Peirce. Nation, Apr. 23, 1914. Vol. 98, p. 466.

National Academy of Sciences. Nation, Apr. 30, 1914. Vol. 98, pp. 505-507.

The evolution of Mt. Desert. Nation, Sept. 17, 1914. Vol. 99, pp. 347-348.

Count Rumford, scientist and philanthropist. Jour. Home Econ., Oct. 1914. Vol. 6, pp. 344-352.

National Academy of Sciences. Nation, Dec. 17, 1914. Vol. 99, pp. 721-722.

Annual meeting of the National Academy of Sciences, 1915. Nation, Apr. 29, 1915. Vol. 100, pp. 475-476.

The National Academy of Sciences: important papers on aerial transmission, evolution, heredity, and other subjects. Nation, Nov. 25, 1915. Vol. 101, pp. 632-633.

Nobel prize-winners in America. Nation, Dec. 9, 1915. Vol. 101, pp. 687-688.

National Academy of Sciences. Nation, May 18, 1916. Vol. 102, pp. 549-550.

Scientific appointments under the government. Science, Nov. 10, 1916. N.S. Vol. 44, pp. 675-676.

National Academy of Sciences: autumn meeting, 1916, Boston. Nation, Dec. 14, 1916. Vol. 103, pp. 569-570.

Symposium on aeronautics: dynamical aspects. Amer. Philos. Soc. Proc., 1917. Vol. 56, pp. 161-167.

Foreign vs. American ideals of citizenship. Education, Je. 1918. Vol. 38, pp. 772-774.

Dynamics of the rifle fired at the shoulder. Physical Rev., Feb. 1919. Ser. 2, Vol. 13, p. 164. (Abstract.)

Interior ballistics by a new gun indicator. Physical Rev., Feb. 1919. Ser. 2, Vol. 13, p. 164. (Abstract.)

A mechanically blown wind instrument. Physical Rev., Feb. 1919. Ser. 2, Vol. 13, p. 164.

Tables of the zonal spherical harmonic of the second kind Q1(z) and Q1′(z). (With Willard Fisher.) Nat. Acad. Sci. Proc., Mar. 1919. Vol. 5, pp. 79-82.

Letter to Harvard Alumni Bulletin, Mar. 13, 1919. Vol. 21, pp. 466-469.

A complete apparatus for absolute acoustical measurements. Nat. Acad. Sci. Proc., May, 1919. Vol. 5, pp. 173-179.

Also in Amer. Inst. Elec. Engin. Proc., Jl. 1919. Vol. 38, pp. 889-900.

A new instrument for measuring pressures with a gun. Nat. Acad. Sci. Proc., Jl. 1919. Vol. 5, pp. 259-263. (With L. T. E. Thompson.)

On the angle of repose of wet sand. Nat. Acad. Sci. Proc., Jl. 1919. Vol. 5, pp. 263-265.

Acoustical impedance, and the theory of horns and of the phonograph. Nat. Acad. Sci. Proc., Jl. 1919. Vol. 5, pp. 275-282.

On the possible form of the equation of state of powder gases. Nat. Acad. Sci. Proc., Jl. 1919. Vol. 5, pp. 286-288.

Some considerations on the ballistics of a gun of seventy-five-mile range. Amer. Philos. Soc. Proc., 1919. Vol. 58, pp. 373-381.

On a new (?) method in exterior ballistics. Amer. Philos. Soc. Proc., 1919. Vol. 58, pp. 382-385. (With Mildred Allen.)

Einstein and the man in the street. The Review, Jan. 31, 1920. Vol. 2, pp. 114-116.

Concerning ballistics. Science, Apr. 9, 1920. N.S. Vol. 51, pp. 368-369.

On the Springfield rifle and the Leduc formula. Nat. Acad. Sci. Proc., Je. 1920. Vol. 6, p. 289.

On the connection of the specific heats with the equation of state of a gas. Nat. Acad. Sci. Proc., Je. 1920. Vol. 6, pp. 302-306.

Experiments on the vibration of air in conical horns. Nat. Acad. Sci. Proc., Je. 1920. Vol. 6, pp. 316-320.

Research and organization. Weekly Rev., Je. 30, 1920. Vol. 2, pp. 686-687.

Transverse vibrations of rods. Science, Aug. 13, 1920. N.S. Vol. 52, p. 154.

Efficiency in thermal calculations. Science, Aug. 20, 1920. N.S. Vol. 52, pp. 175-176.

On a condition for Helmholtz's equation similar to Lamé's. Nat. Acad. Sci. Proc., Oct. 1920. Vol. 6, pp. 605-607.

Some new methods in interior ballistics. Nat. Acad. Sci. Proc., Nov. 1920. Vol. 6, pp. 648-659.

Education and learning in America. Scientific Mo., Nov. 1920. Vol. 11, pp. 419-428.

Albert A. Michelson, physicist. Weekly Rev., Jan. 12, 1921. Vol. 4, pp. 31-32.

An adjustable embouchure. Science, Feb. 25, 1921. N.S. Vol. 53, pp. 188-189.

Galileo and Wood. Science, Mar. 4, 1921. N.S. Vol. 53, pp. 212-213.

Upsetting Newton. Weekly Rev., May 14, 1921. Vol. 4, p. 461.

Madame Curie and others. Weekly Rev., May 21, 1921. Vol. 4, pp. 490-491.

O quanta! Weekly Rev., Je. 4, 1921. Vol. 4, pp. 537-538.

Absolute measurements of sound. An address before the Royal Institute of Great Britain June 10, 1921. Engineering, Je. 24, 1921. Vol. 3, pp. 763-765.

Same in Nature, Jl. 8, 1922. Vol. 110, pp. 42-45.

Same in Science, Aug. 31, 1923. N.S. Vol. 58, pp. 149-152.

On the vibrations of gun-barrels. Physical Rev., Sept. 1921. Ser. 2, Vol. 18, p. 164.

On steering an automobile around a corner. Nat. Acad. Sci. Proc., May 1922. Vol. 8, pp. 100-106.
Bureau of Standards. Science, Aug. 11, 1922. N.S. Vol. 56, pp. 170-171.
Experimental results in interior ballistics. Physical Rev., Mar. 1923. Ser. 2, Vol. 21, p. 378.
Note on an experimental problem of the late A. G. Webster. Nat. Acad. Sci. Proc., Dec. 15, 1923. Vol. 9, pp. 399-401.
The partial differential equations of mathematical physics. New York, G. E. Stechert & Co., 1924. 400 pages approximately. Edited by S. J. Plimpton, Ph.D., Asst. Professor of Physics, Worcester Polytechnic Institute. (The manuscript was nearly complete as it was left by the author, but some *lacunae* have been filled by the editor from an intimate acquaintance with Dr. Webster's original intentions.)

Reviews

Electric waves by H. Hertz. London, Macmillan, 1894. Physical Rev., 1894. Vol. 3, pp. 234-239.
Elements of the mathematical theory of electricity and magnetism by J. J. Thomson. Cambridge Univ. Press, 1895.
Electricity and magnetism by F. A. Nipher. St. Louis, J. L. Boland Bk. and Stat. Co., 1895. Science, Dec. 13, 1895. N.S. Vol. 2, pp. 809-812.
Die Principien der Mechanik in neuen Zusammenhange dargestellt von H. Hertz. Leipzig, Barth, 1894. Physical Rev., 1896. Vol. 3, pp. 73-78.
Handwörterbuch der Naturwissenschaften brsg. von E. Korschelt. Jena, Fischer, 1912. Science, Aug. 15, 1913. N.S. Vol. 38, pp. 230-233.
American Academy of arts and sciences. Report of the librarian from 1915 to 1923. Proceedings of the Academy, Aug. 1915, p. 375; Dec. 1916, p. 834; Oct. 1917, p. 816; Sept. 1918, p. 767; Sept. 1919, pp. 399-400; Nov. 1920, p. 495; Sept. 1921, pp. 390-391; Nov. 1922, pp. 451-452; Sept. 1923, p. 589.
Reports of committees of the British Association for the Advancement of Science, of which Dr. Webster was a member. Report of the 68th meeting, 1898, pp. 145-158; Report of the 83d meeting, 1913, pp. 87-130; Report of the 84th meeting, 1914, pp. 75-102; Report of the 85th meeting, 1915, pp. 27-38; Report of the 86th meeting, 1916, pp. 59-126; Report of the 87th meeting, 1919, pp. 43-81.

Edward S. Dana

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Edward Salisbury Dana, eminent mineralogist, was born November 16, 1849, in New Haven, Connecticut. That he should become an eminent scientist seemed foreordained by inheritance and background. On both sides of his family he came of distinguished scientific lineage. His father was James Dwight Dana, renowned in his younger years as a zoologist and mineralogist, from 1850 to 1890 Silliman Professor of Natural History at Yale University, and as time went on universally recognized as the foremost geologist of America. The elder Dana had entered Yale with the class of 1833, attracted by the fame of Benjamin Silliman, who was then in the prime of his powers as an inspiring teacher of chemistry and geology. During Dana's college days, and after his graduation, he had the good fortune to become associated with Professor Silliman. The tie was later strengthened by his marriage in 1844 with Henrietta Frances, a daughter of Professor Silliman. Six children were born of this marriage, and of these, Edward Salisbury Dana was the eldest. He was named in honor of one of his father's closest friends, Edward E. Salisbury, Professor of Sanskrit, who when it had appeared that James D. Dana would accept a call to Harvard had suggested the founding of a Silliman Professorship of Natural History at Yale and had generously contributed to it, with the understanding that Dana should be the first incumbent.

Edward S. Dana was prepared for college at Hopkins Grammar School in New Haven, and graduated from Yale College with the class of 1870. He continued his studies, chiefly in mineralogy, for the next two years under the guidance of George J. Brush, Professor of Mineralogy in the Sheffield Scientific School. He then went abroad for two years. During the first year he studied at Heidelberg, where he found the kindness of the professors "very great." During the first term he attended

Bunsen's lectures on Experimentalchemie and worked six hours daily in Bunsen's laboratory, learning analytical methods. Near the end of the term he did some original work also, such as measuring with W. G. Mixter the specific heats of silicon, boron, and zirconium, using Bunsen's own calorimeter. During the second term he attended the lectures of Leonhard on mineralogy, Kirchoff on physics, Kopp on crystallography, Neumayr on geology, Blum on lithology, and Klein on optical mineralogy; altogether he heard 300 lectures that semester.

In the summer of 1873 he went to Vienna chiefly to learn optical mineralogy and microscopical petrography, which were the principal objects of his trip to Europe. He studied under Tschermak and Schrauf. The young Dana was astounded to learn among other things that identical rocks should be given different names according to their geologic ages. "I am told," he wrote his father, "that it is absurd for me to speak of Triassic dolerite, for such a thing *does not exist,* the rock must be either diabase or augitporphyr." He thought this extremely illogical, if not absurd; and though sixty-five years have passed, the effects of the illogicality have not yet been entirely removed from the German literature. The instruction was largely on the let-alone principle. "The moral of it all is that one must depend after all upon himself if he will learn anything—which is no very new discovery in the world," Dana sagely concluded.

The extant letters of Dana written during his Wanderjahre contain many extremely interesting pen pictures of such famous leaders in science as Bunsen, Kirchoff, Kopp, Suess, Neumayr, and Tschermak. There are many incisive comments on methods of instruction, evaluation of lecture courses, and on text books: manifestly, the education of Edward S. Dana was proceeding apace.[1]

Long afterwards, when the close of the World War had reduced the scientists of Vienna to abject want, Dana put himself at the head of a movement to aid the mineralogists. From the summer of 1920 onward members of the Mineralogical Society

[1] The writer is greatly indebted to Miss Maria T. Dana, sister of Edward S. Dana, for access to the letters written by her brother and for other gracious aid in preparing this biography.

of America and others sent substantial pecuniary aid; it was particularly gratifying to Dana thus to help make more comfortable the last years of the life of Tschermak, who died in 1927, and of those of his wife. Dana had strong charitable feelings and was a heavy contributor to the Community Chest of his city.

Early in April, 1874, Dana returned from Europe to New Haven to continue his work at Yale. He took the M.A. degree in that year and continued his studies for the doctor's degree. During the summer of 1875 he was attached to the exploring party of Capt. William Ludlow, of the Corps of Engineers, U. S. Army. His classmate, George Bird Grinnell, was also a member of the party and reported on the zoology and paleontology. Both men were volunteers, traveling at their own expense, and received no compensation. It was evidently an exciting summer, for much of the country swarmed with Indians—with hostile or predatory Sioux and with Crows, who, friendly to the whites, were at war with the Sioux. Geology had to be done with hammer in one hand and rifle in the other. Buffalo and other big game were abundant on the plains, and the party was shocked by the reckless way in which the animals were being destroyed. At the Geyser basins, also, the party was appalled by the vandalism of the sight-seers, for although the Yellowstone Park had only been made known to the world a scant five years before, visitors were already numerous, and vandals of both sexes were busily chopping with axes and prying off the ornamental work of the geyser craters! The geologic results of this rapid reconnaissance trip were published in 1876 as part of Capt. Ludlow's report.

In 1876 Dana received the Ph.D. degree, his dissertation being on "The Trap Rocks of the Connecticut Valley." His graduate years had been a time of great research activity, and besides the geologic report on the Montana reconnaissance already mentioned he had published seven important mineralogic studies. One of the first of these, "On the Composition of the Labradorite Rocks of Waterville, New Hampshire," in 1872, dealt with the compositions of the individual components of a rock and was a pioneer in that branch of research in this country.

The chief rock was thought to represent a new type ("ossipite"), but on being thin-sectioned in Vienna, proved to be, as Tschermak had suspected, an olivine gabbro.

Although Dana was made Curator of Mineralogy in the Yale University Mineral Collection in 1874, yet on graduation there was no opportunity for him to teach mineralogy at the University, and he accepted a tutorship in mathematics, physics, and chemistry in Yale College. Soon we have the anomaly of a man internationally famous as a mineralogist, teaching physics and continuing to do so during the long span of his academic tenure. In 1879 he was made Assistant Professor of Natural Philosophy; in 1890 he became Professor of Physics; and he served in that capacity until he retired in 1917.

Professor D. A. Kreider, one of Dana's colleagues in the Physics Department, has given us this picture:

"Professor Dana was conspicuously successful as a teacher. From 1874 to 1917 he was in charge of the course in elementary Physics in Yale College, perhaps the most arduous course to handle successfully with the general student. In spite of the inherent difficulties encountered by beginners in the subject, combined with the mathematical requirements, the course in Physics under Professor Dana continued to draw large divisions even during the development of the elective system and its introduction of many courses in which the standards were much less exacting.

"Always bright and vivacious, Professor Dana took his position at the lecture table with a brisk step and pleasant smile. With a minimum of formality he picked up the threads from the previous exercise and proceeded without notes, at high speed, and with the rapt attention of the students to the end of the hour. His method was first, by a quiz, to locate the boundary between understanding and uncertainty, and to excite the student's interest. This led naturally to a discussion in which the class was induced to assist. Dana's own contributions to these discussions were marvels of lucidity. Dexterous with the crayon, he would, with the minimum strokes, clarify every essential detail. Finally, with the student prepared to comprehend what he was to see, there followed such experimental demonstration as the relatively limited apparatus of his day afforded. He was a master in every form of presentation. Admittedly his method was not economical of time or energy, but it was effective."

As a byproduct of his activities as a teacher of undergraduate Physics, he produced in 1881 "A Text Book of Elementary Mechanics for the Use of Colleges and Schools." It was an excellent book and was used successfully for many years.

As a member of the faculty of Yale College (be it remembered that in those days "Yale College" and "The Sheffield Scientific School" were practically autonomous units in Yale University) Dana became exceedingly influential and took the keenest interest in its administrative affiairs. Dean Jones, in his annual report for 1916-1917, paid his tribute to Professor Dana:

"No member of the Faculty has been more influential in shaping the Course of Study. His services as chairman of that important committee, and as chairman of the Ways and Means Committee have long been recognized and appreciated by his colleagues. As the senior member of the Permanent Officers he gave his best thought and energy to the educational and financial problems of the College. Tolerant, sagacious, and tactful, with exact knowledge of the history of the growth and development of all departments of the University, he was an indispensable member of every committee which has had to do with interdepartmental relations."

Dana's main interest, however, was in mineralogy and especially in crystallography. In 1878 began appearing the celebrated Branchville papers, dealing with the remarkable mineral locality at Branchville, Conn. Four of these papers came out between 1878-1880, and the fifth and last in 1890. Fourteen minerals were described, of which nine were newly recognized species. These papers set a new standard for mineralogical research in this country. Notable is the skillful use of optical and microscopical methods that Dana made to supplement the usual mineralogical and chemical methods; in this he was in advance of his times, and the value of these auxiliaries was not generally appreciated until several decades later.

Dana's fame as a mineralogist, however, rests mainly on the books that he wrote. In 1877 appeared his Textbook of Mineralogy, which immediately took rank as the leading book in English. A revised and greatly expanded version appeared in 1898 and was distinguished among other things for a lucid

exposition of the principles of optical mineralogy, which was long without a peer. Subsequently two later editions of "Dana's Textbook of Mineralogy" were prepared by W. E. Ford, the latest having been issued in 1932. Other books of his are "Minerals, and How to Study Them (a book for beginners)," written in 1895, and "A System of Mineralogy," known to all mineralogists and geologists as "Dana's System."

The "System" will ever remain Dana's great monument. Let us consider briefly the history of the "System," the most influential work ever published in mineralogy. The first edition of this great book had been published by his father in 1837, a volume of 580 pages. In the fourth edition of the "System," published in 1854, J. D. Dana abandoned the classification of minerals that he had theretofore used, and proposed a classification based on chemical principles. This classification was universally accepted, and is essentially that in use today. Rossiter W. Raymond, writing of the days when he was a student at the Royal Academy of Mines in Freiberg, said "I remember well the thrill of patriotic pride with which I heard my instructor in mineralogy—himself a man of world-wide reputation—declare in that department that the best book ever published was the wonderful Mineralogy of Dana."

The fifth edition appeared in 1868, and was the most complete treatise that had ever been attempted. Edward S. Dana undertook the task of preparing the sixth edition, and it was issued in 1892. During the twenty-four years that had passed since the previous edition, the science of Mineralogy had progressed unprecedentedly. Nearly one thousand new names had been introduced during the interval: "Unfortunately," said Dana, "not all 'new species,' although this has been claimed for most of them." The importance of the optical properties of minerals and of optical methods of investigation, owing to the rapid growth of petrography, had become recognized. Chemical mineralogy had made great strides and the synthetic production of minerals had thrown much light on problems of genesis. The new edition, a volume of 1134 pages, contained half again as much matter as the previous edition.

The axial ratios of each mineral species were recalculated from the data of the original observer and from these the important angles of all the common forms were calculated—a herculean task in itself—and some 1400 crystal drawings were made. In these, and many other respects, the sixth edition was essentially a new book. Forty years of use have disclosed astonishingly few errors in it, even of a typographical nature. Considering that the work was done essentially single-handed, it was a supreme achievement. Three appendices have been issued (1899, 1909, and 1915) to keep the "System" up-to-date. At the present time the seventh edition is being prepared under the supervision of Professors Palache and Ford, for the content of mineralogy has become so great that no one man can hope to encompass the task of revision. Such a feat as Dana's we shall not see again.

The recognition accorded Dana's System has been world-wide. As Professor Charles Palache, of Harvard, has written: "The Dana System is the Bible of every mineralogical institute which I have ever been in," and this feeling is shared by all geologists as well.

Dana was married on October 2, 1883, to Caroline, daughter of William Brooks Bristol, a lawyer prominent in New Haven; she died in 1916. Three children were born to them: Mary Bristol in 1886, James Dwight in 1889, and William Bristol in 1896; both sons are lawyers.

The great task of bringing out the sixth edition of the "System," coupled with his many other activities, proved to be a breaking strain. His health gave way in 1894, and Dana was obliged to cease from his labors. Accompanied by his wife, he went to Europe to recover his health. Again, in 1902, he was obliged to seek complete rest for a year. In these later years the state of his health restricted his activities chiefly to teaching, administrative, and editorial work.

Dana became one of the editors of the *American Journal of Science* in 1875, and to the very end of his life it remained one of the prime objects of his solicitude. The *Journal* had been founded in 1818 by his grandfather Benjamin Silliman; from

1846 until the death of Benjamin Silliman, it was run jointly by Benjamin Silliman, his son, and his son-in-law, James D. Dana. In 1885 Benjamin Silliman, Jr., retired, and on the death of James D. Dana in 1895, Edward S. Dana assumed the full burden, editorial and financial. In 1926 a severe illness, during which his life was despaired of, made necessary a lightening of the load, and Dr. Ernest Howe generously consented to become co-editor; he relieved Dana of the heavier duties and ran the *Journal* with rare skill until his death in 1932. Dr. R. S. Lull then became co-editor and since the death of Dana on June 16, 1935, has become the editor. Thus up to the time of his death Dana was actively and keenly interested in the affairs of the *Journal*. With his passing there came to an end the longest scientific dynasty in America, extending from 1818 to 1935.

Many honors were conferred on him. He was a member of numerous mineralogical and geological societies. In 1884 he was elected to the National Academy of Sciences. In 1925 the Mineralogical Society of America made him Honorary President for life.

On the anniversary of his eightieth birthday, the Academy of Sciences of Vienna sent to Edward Salisbury Dana this message of greeting, simply and feelingly worded; it is in itself a noble memorial.

"To our highly honored Colleague:

"In accordance with a beautiful custom, the Academy of Sciences in Vienna sends to you the most heartfelt good wishes for the 16th of November, 1929, the day on which you complete your eightieth year in perfect physical and mental vigor. May the years that lie behind you so rich in scientific achievement be followed by a long and happy autumn, made beautiful and enhanced by the love and honor of all who are permitted to have a part in your life. Among these counts itself the Academy of Sciences in Vienna, which carries proudly the name Edward Salisbury Dana on the roll of its foreign members.

"Such an anniversary prompts us to look back into the past, and most would be inclined to consider the year 1876 in which you were awarded the degree of Doctor of Philosophy by Yale University as the beginning of your scientific career. Indeed from that year onward, the chain of well-wrought contributions

was forged link by link, which, dealing mainly with the varied minerals of your country, drew the attention of your fellow scientists and soon caused them to recognize you as the master and leader of American mineralogists.

"However, to us in Vienna the year 1876 does not have that significance. With joy we can establish through documentary evidence that forerunners of those distinguished contributions had originated three years earlier in one of the famous laboratories of Vienna, the old Hof-Mineralien Cabinet, and were published in the Vienna scientific journal, the "Mineralogische Mitteilungen gesammelt von G. Tschermak," 1874, as the first of a long succession of increasingly brilliant contributions. So far back extends the relationship of yourself to Vienna, and we of Vienna may rightfully claim Edward S. Dana as one of our own.

"As collaborator in the later editions of the widely celebrated 'A System of Mineralogy,' of your father James Dwight Dana, you were well prepared to revise this work and to recast it for a form suitable to modern times. This revision you completed in 1892 and have produced a fundamental treatise, which in uniformity of treatment, in authoritativeness, and in completeness is almost without a peer and which enjoys even in old Europe not only because of its careful accounts of American deposits the highest regard and the widest distribution.

"No less favorably than by your own contributions to knowledge have you influenced the progress of science in your country as the editor of the highly esteemed *American Journal of Science,* which presents to the scientific world the progress of your countrymen in the realm of the natural sciences, especially in geology. Because of the careful choice of articles, the accuracy of references, and the distinguished presentation, the readers of the American Journal have ever experienced profound satisfaction; and the position of the Journal as leader is unquestioned.

"The members of the learned circles of Vienna have yet another very special reason for remembering you with honor on this your anniversary. Since 1873 bonds of personal friendship have existed between you and a number of physicists and mineralogists in Vienna.

"With this circle of friends you have kept faith during one of the saddest times that has ever befallen Vienna and Austria. In the fatal years when the collapsing State was unable to keep Austrian scholars of world-wide fame and their families from bitter want, you have remembered your friends, and with the

courage of a kind heart have been one of the first to gather funds for your suffering colleagues and their dependents in Vienna in order to ameliorate their distress. The Academy of Vienna can not fail on this present occasion to acknowledge this publicly, and it asks you to accept its gratitude for the help and sympathy shown through these many years.

Vienna, November 16, 1929."

BIBLIOGRAPHY

OF EDWARD S. DANA

1872

On the composition of the labradorite rocks of Waterville, New Hampshire. Amer. Jour. Sci., 3d ser., vol. 3, pp. 48-50; Yale Bicentennial Publications, Contributions to Mineralogy and Petrography, pp. 387-390 (1901).

On the datolite from Bergen Hill, New Jersey. Amer. Jour. Sci., 3d ser., vol. 4, pp. 16-22.

On a crystal of andalusite from Delaware County, Pennsylvania. Amer. Jour. Sci., 3d ser., vol. 4, p. 473.

1873

(With W. G. Mixter) Specifische Wärme des Zirkoniums, Siliciums und Bors. Annalen der Chemie und Pharmacie, vol. 169, pp. 388-392.

1874

(With A. Schrauf) Notiz über die thermoelektrischen Eigenschaften von Mineralvarietäten. Sitzungsberichte der Akademie der Wissenschaften Wien, Erste Abtheilung, Bd. 69, pp. 142-159; Proc. Amer. Assn. Adv. Sci., 23d meeting (1874), pp. 66-80 (1875); Amer. Jour. Sci., 3d ser., vol. 8, pp. 255-267.

Ueber Datolith. Mineralogische Mittheilungen, Wien, vol. 4, pp. 1-6.

Morphologische Studien über Atacamit. Mineralogische Mittheilungen, Wien, vol. 4, pp. 103-108.

Notiz über Calcitdrilling nach 2R. Mineralogische Mittheilungen, Wien, vol. 4, p. 180.

On the trap rocks of the Connecticut Valley. Amer. Jour. Sci., 3d ser., vol. 8, pp. 390-392; Proc. Amer. Assn. Adv. Sci., 23d meeting (1874), pt. 2, pp. 45-47 (1875).

1875

Second appendix to the fifth edition of Dana's Mineralogy. New York, 64 pages.

[Progress in] mineralogy. Annual Record of Science and Industry for 1874, pp. lxv-lxvii.

Preliminary notice of chondrodite crystals from the Tilly Foster iron mine, Brewster, New York. Amer. Jour. Sci., 3d ser., vol. 9, pp. 63-64.

On the chondrodite from the Tilly Foster iron mine, Brewster, New York. Trans. Conn. Acad. Arts and Sci., vol. 3, pp. 67-96; Amer. Jour. Sci., 3d ser., vol. 10, pp. 89-103.

[Abstract of a memoir on the Origin of the Alps, by Eduard Suess.] Amer. Jour. Sci., 3d ser., vol. 10, pp. 446-451.

1876

(With George Bird Grinnell) Geological Report. *In* Ludlow, William. Report of a reconnaissance from Carroll, Montana Territory, to the Yellowstone National Park. Washington, pp. 89-126; *in* Annual Report of the Chief Engineer, United States [War Department], for 1876 (44th Congress, 2d Session, House Executive Document No. 1, pt. 2, vol. 2, pt. 3), Appendix NN, pp. 657-694.

On the optical character of the chondrodite of the Tilly Foster mine, Brewster, New York. Amer. Jour. Sci., 3d ser., vol. 11, pp. 139-140.

On the samarskite, Mitchell County, North Carolina. Amer. Jour. Sci., 3d. ser., vol. 11, pp. 201-204.

On new twins of staurolite and pyrrhotite. Amer. Jour. Sci., 3d ser., vol. 11, pp. 384-387.

Mineralogical Notes No. IV. On the association of crystals of quartz and calcite in parallel position, as observed on a specimen from the Yellowstone Park. Amer. Jour. Sci., 3d ser., vol. 12, pp. 448-451; Zeitschrift für Krystallographie, vol. 1, pp. 39-42 (1877).

(With George Bird Grinnell) On a new Tertiary lake basin. Amer. Jour. Sci., 3d ser., vol. 11, pp. 126-128.

1877

A textbook of mineralogy, with an extended treatise on crystallography and physical mineralogy. New York, 485 pages.

On the crystalline form of the hydrous and anhydrous varieties of ethylidenargentamine-ethylidenammonium nitrate. Amer. Jour. Sci., 3d ser., vol. 14, pp. 198-201.

On the occurrence of garnets with the trap of New Haven, Connecticut. Amer. Jour. Sci., 3d ser., vol. 14, pp. 215-218.

1878

(With George J. Brush) Notice of three new phosphates from Fairfield County, Connecticut. Amer. Jour. Sci., 3d ser., vol. 15, pp. 398-399.

(With George J. Brush) Notice of a fourth new phosphate from Fairfield County, Connecticut. Amer. Jour. Sci., 3d ser., vol. 15, pp. 481-482.

(With George J. Brush) On a new and remarkable mineral locality in Fairfield County, Connecticut, with a description of several new species occurring there. First Paper. Amer. Jour. Sci., 3d ser., vol. 16, pp. 33-46, 114-123; Zeitschrift für Krystallographie, vol. 2,

pp. 529-551; Yale Bicentennial Publications, Contributions to Mineralogy and Petrography, pp. 48-71 (1901).

1879

(With George J. Brush) On the mineral locality in Fairfield County, Connecticut, with the description of two additional new species. Second Paper. Amer. Jour. Sci., 3d ser., vol. 17, pp. 359-368; Zeitschrift für Krystallographie, vol. 3, pp. 577-587; Yale Bicentennial Publications, Contributions to Mineralogy and Petrography, pp. 72-80 (1901).

(With George J. Brush) On the mineral locality in Fairfield County, Connecticut. Third Paper. Amer. Jour. Sci., 3d ser., vol. 18, pp. 45-50; Zeitschrift für Krystallographie, vol. 4, pp. 69-75 (1880); Yale Bicentennial Publications, Contributions to Mineralogy and Petrography, pp. 81-85 (1901).

1880

(With George J. Brush) Note on the relation between childrenite and eosphorite. Amer. Jour. Sci., 3d ser., vol. 19, pp. 316-317.

(With George J. Brush) On crystallized danburite from Russell, Saint Lawrence County, New York. Amer. Jour. Sci., 3d ser., vol. 20, pp. 111-118; Zeitschrift für Krystallographie, vol. 5, pp. 183-190 (1881).

(With George J. Brush) On the mineral locality at Branchville, Connecticut. Fourth Paper. Spodumene and the results of its alteration. Amer. Jour, Sci., 3d ser., vol. 20, pp. 257-285, 351; Zeitschrift für Krystallographie, vol. 5, pp. 191-221 (1881); Yale Bicentennial Publications, Contributions to Mineralogy and Petrography, pp. 86-104 (1901).

Microscopical examination of samples of commercial arsenic and the practical results to which it leads. Jersey City (Linn. and Co.), 36 pages. Reviewed in Zeitschrift für Krystallographie, vol. 5, pp. 609-610 (1881).

1881

A text-book of elementary mechanics for the use of colleges and schools. New York, 291 pages.

On the emerald green spodumene from Alexander County, North Carolina. Amer. Jour. Sci., 3d ser., vol. 22, pp. 179-182.

1882

Third appendix to the fifth edition of Dana's System of Mineralogy. New York, 136 pages.

On crystals of monazite from Alexander County, North Carolina. Amer. Jour. Sci., 3d ser., vol. 24, pp. 247-250; Zeitschrift für Krystallographie, vol. 7, pp. 362-365.

1883

On the stibnite from Japan. Amer. Jour. Sci., 3d ser., vol. 26, pp. 214-221; Zeitschrift für Krystallographie, vol. 9, pp. 29-37 (1884).

1884

A textbook of mineralogy, with an extended treatise on crystallography and physical mineralogy. New York, 521 pages. The title page describes this as "10th edition, newly revised and enlarged." It adds a supplementary chapter on "Improved instruments for the measurement of the angles of crystals," one on "Cohesion and elasticity, specific gravity, light," and a third on new species of minerals.

[Record of recent scientific progress in] mineralogy. Smithsonian Inst. Ann. Rept. (1882), pp. 533-549.

A crystallographic study of the thinolite of Lake Lahontan. U. S. Geol. Sur., Bull. 12, 34 pages.

On the crystalline form of the supposed herderite from Stoneham, Maine. Amer. Jour. Sci., 3d ser., vol. 27, pp. 229-232; Zeitschrift für Krystallographie, vol. 9, pp. 278-282.

Mineralogical notes. Amer. Jour. Sci., 3d ser., vol. 27, pp. 479-481; Zeitschrift für Krystallographie, vol. 9, pp. 283-285.

1885

[Record of scientific progress, 1883] Mineralogy. Smithsonian Inst., Ann. Rept. (1883), pp. 661-679.

[Record of scientific progress, 1884] Mineralogy. Smithsonian Inst., Ann. Rept. (1884), pp. 543-561.

(With S. L. Penfield) Mineralogical Notes. Amer. Jour. Sci., 3d ser., vol. 30, pp. 136-139; Zeitschrift für Krystallographie, vol. 11, pp. 308-311 (1886).

1886

[Record of scientific progress, 1885] Mineralogy. Smithsonian Inst., Ann. Rept. (1885), pp. 687-712.

Catalogue of the collection of meteorites in the Peabody Museum of Yale College. Amer. Jour. Sci., 3d ser., vol. 32, Appendix to September number, pp. 1-4.

On the crystallization of gold. Amer. Jour. Sci., 3d ser., vol. 32, pp. 132-138; Zeitschrift für Krystallographie, vol. 12, pp. 275-281.

(With S. L. Penfield) On two hitherto undescribed meteoric stones [Utah and Cape Girardeau, Missouri]. Amer. Jour. Sci., 3d ser., vol. 32, pp. 226-231.

On the brookite from Magnet Cove, Arkansas. Amer. Jour. Sci., 3d ser., vol. 32, pp. 314-317.

Mineralogical notes. Amer. Jour. Sci., 3d ser., vol. 32, pp. 386-390; Zeitschrift für Krystallographie, vol. 12, pp. 459-460 (1887).

On the crystallization of native copper. Amer. Jour. Sci., 3d ser., vol. 32, pp. 413-429; Zeitschrift für Krystallographie, vol. 12, pp. 569-587 (1887).

Ueber den Columbit. Zeitschrift für Krystallographie, vol. 12, pp. 266-274; [abstract] Amer. Jour. Sci., 3d ser., vol. 32, pp. 386-387.

1888

A textbook of mineralogy, with an extended treatise on crystallography and physical mineralogy. New York, 537 pages. "14th edition, newly revised and enlarged." Four chapters are added, and Appendix E ("Tables to be used in the determination of minerals"); the book is also re-paged and re-indexed.

(With S. L. Penfield) On the crystalline form of polianite. Amer. Jour. Sci., 3d ser., vol. 35, pp. 243-247; Zeitschrift für Krystallographie, vol. 14, pp. 166-172.

Preliminary notice of beryllonite, a new mineral. Amer. Jour. Sci., 3d ser., vol. 36, pp. 290-291.

1889

[Record of scientific progress] Mineralogy in 1886. Smithsonian Inst. Ann. Rept. (1887), pt. 1, pp. 449-476.

(With H. L. Wells) Description of the new mineral, beryllonite. Amer. Jour. Sci., 3d ser., vol. 37, pp. 23-32; Zeitschrift für Krystallographie, vol. 15, pp. 275-284.

Contributions to the petrography of the Sandwich Islands. Amer. Jour. Sci., 3d ser., vol. 37, pp. 441-467.

1889-1891

[Definitions of terms in Physics and Mineralogy in] The Century Dictionary and Cyclopedia.

1890

Mineralogy for 1887 and 1888. Smithsonian Inst., Ann. Rept. (1888), pp. 455-473.

On the barium sulphate from Perkins' Mill, Templeton, Province of Quebec. Amer. Jour. Sci., 3d ser., vol. 39, pp. 61-65; Zeitschrift für Krystallographie, vol. 17, pp. 392-398.

(With H. L. Wells) On some selenium and tellurium minerals from Honduras. Amer. Jour. Sci., 3d ser., vol. 40, pp. 78-82.

(With George J. Brush) On the mineral locality at Branchville, Connecticut. Fifth Paper. Amer. Jour. Sci., 3d ser., vol. 39, pp. 201-216; Zeitschrift für Krystallographie, vol. 18, pp. 7-23, 688 (1891); Yale Bicentennial Publications, Contributions to Mineralogy and Petrography, pp. 105-120 (1901).

(With W. F. Hillebrand) Additional notes on the tyrolite from Utah. Amer. Jour. Sci., 3d ser., vol. 39, pp. 271-273.

1891

[Definitions of terms in Geology and Mineralogy in] Webster's International Dictionary.

Petrography of the Hawaiian Islands; in Characteristics of Volcanoes, by J. D. Dana, pp. 218-354.

1892

The system of mineralogy of James Dwight Dana, 1837-1868, sixth edition. New York, lxiii + 1134 pages.

1893

Catalogue of American localities of minerals. New York, 51 pages. Reprinted from the sixth edition of the Dana *System*. Another printing was made in 1898.

1895

Minerals and how to study them. New York, 380 pages.

James Dwight Dana. Amer. Jour. Sci., 3d ser., vol. 49, pp. 329-356.

1898

A textbook of mineralogy, with an extended treatise on crystallography and physical mineralogy. New York, 593 pages. This is commonly called the second edition. According to the title page, the book was "entirely rewritten and enlarged."

1899

First appendix to the sixth edition of Dana's System of Mineralogy. New York, 75 pages.

1909

(With W. E. Ford) Second appendix to the sixth edition of Dana's System of Mineralogy. New York, 114 pages.

1912

George Jarvis Brush. Amer. Jour. Sci., 4th ser., vol. 33, pp. 389-396.

1918

The American Journal of Science from 1818 to 1918. Amer. Jour. Sci., 4th ser., vol. 46, pp. 1-44; *in* A century of science in America, with special reference to the American Journal of Science, 1818-1918. New Haven, pp. 13-59.

[Editor] A century of science in America. New Haven, 458 pages.

1921

Minerals and how to study them; a book for beginners in mineralogy. Second, revised edition. New York, 380 pages.

1924

Biographical memoir, George Jarvis Brush, 1831-1912. Nat. Acad. Sci., Mem., vol. 17, pp. 105-112.

1926

Editorial note. Amer. Jour. Sci., 5th ser., vol. 11, pp. 514-516.

1927

Hofrat Professor Dr. Gustav Tschermak, 1836-1927. Amer. Jour. Sci., 5th ser., vol. 14, p. 87; Amer. Mineralogist, vol. 12, p. 293.

1928

Geheimrat Professor Dr. Paul Heinrich Ritter von Groth. Amer. Jour. Sci., 5th ser., vol. 15, p. 285.

1932

(With C. R. Longwell) Walks and rides in central Connecticut and Massachusetts. New Haven, 229 pages.

Biographical memoir of Arthur Williams Wright, 1836-1915. Nat. Acad. Sci., Biog. Mem., vol. 15, pp. 241-257.

The celestite locality near Clay Center, Ohio. Amer. Jour. Sci., 5th ser., vol. 23, p. 383.

Many editorial notes and reviews in American Journal of Science, 1875-1935; reviews in Zeitschrift für Krystallographie, 1877-1892.